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**Coal Cleanability
Characterization of Croweburg
Seam Coal**

to

**U.S. Department of Energy
Pittsburgh, Pennsylvania
DE-FC22-90PC89663**

**Electric Power Research Institute
Palo Alto, California
RP1400-25**

CQ-91R103

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Prepared for:

U.S. Department of Energy
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July 19, 1991

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Report No. 91R103

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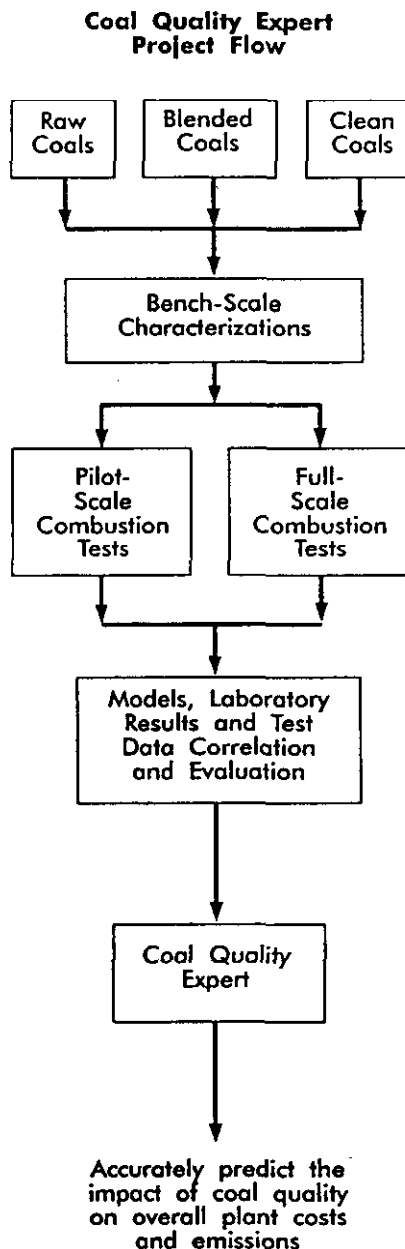
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- Mr. David Turner of Peabody Coal Company and Ms. Sharon Roness of Kerr-McGee provided demographic information and raw coal data for the test coals.
- Under the direction of the Pennsylvania Electric Company which also co-funds the CQE project, the Homer City Coal Laboratory analyzed the test coal samples.
- Dr. Carol Zera of Writing Consultants Associated reviewed and edited this report.

INTRODUCTION



Because the electric power generation industry must meet the ever increasing requirements of regulatory agencies and consumers, coal-fired utilities need a way to evaluate how specific coals will behave in their plants before purchasing them. Taking advantage of state-of-the-art computer technology, the Department of Energy and the Electric Power Research Institute (EPRI), under the Clean Coal Technology Program, are developing the Coal Quality Expert (CQE), a sophisticated yet user-friendly computer software program. CQE can provide the utility industry with a PC expert system to confidently and inexpensively evaluate the potential for coal cleaning, blending, and switching options to reduce emissions while producing the lowest cost electricity. Intended to demonstrate the economics and environmental benefits of cleaning coal, CQE will enhance the use of physically-cleaned U.S. coals to reduce emissions and power production costs.

Data collected and analyzed on raw and cleaned coals during development of CQE will also be used to upgrade EPRI's Coal Quality Information System (CQIS)--a database of coal characteristics and cleaning potential--and Coal Quality Impact Model (CQIM)--a commercialized program that gives the bottom line cost of burning a given coal in a particular boiler.

As part of the overall project, CQ Inc. (a subsidiary of EPRI) is performing Coal Cleanability Characterizations on 20 raw coals (most of which have yet to be identified) used in this project. Of these raw coals, 12 will also undergo extensive cleaning at CQ Inc.'s Coal Quality Development Center.

Coal Cleanability Characterizations are extensive evaluations of a raw coal's size, quality, and predicted cleaning potential. Also included are raw coal liberation studies (which determine the extent to which crushing liberates ash and pyrite) and cleaning studies to evaluate each raw coal's susceptibilities to cleaning in various processes. These studies can help to determine whether cleaning is a cost-effective emissions control alternative. They also can help identify the source of site-specific boiler problems related to a coal's quality. While providing generic information for the coal-producing and electric utility industries, these studies

are designed to satisfy the overall needs of the project and its participants.

The data gathered from these tests and from coal cleaning tests done on project-specified raw coals will be used in bench-scale characterizations to assess raw coal quality, predict and verify the effects of coal cleaning, and finally to predict boiler performance and emissions for a specific coal. Pilot- and six full-scale combustion test burns using the project coals will gather additional data relating to coal quality impacts on specific power plant costs and performance.

The results of the above laboratory and test data will then be evaluated and correlations made among the data to develop new models and validate existing models that will comprise the integrated CQE program. This program will allow detailed predictions of coal quality impacts on total plant capital costs, operating costs, and performance based on inputs from inexpensive bench-scale tests.

Northeastern Station Test Program

Public Service Company of Oklahoma (PSO) is one of the six host utilities involved in this project. Because Oklahoma utilities are mandated by Oklahoma law to burn (on a Btu basis) at least ten percent native Oklahoman coal, PSO is interested in determining to what extent the Oklahoma coal it burns may be responsible for slagging and fouling problems experienced at its Northeastern Station's Units 3 and 4 in Oologah, Oklahoma and if so, whether cleaning the Oklahoma coal can help eliminate these problems. The Croweburg Seam is one of the Oklahoma coal seams burned at the Northeastern Station. This coal is notably different from the coal for which these units were designed. The boilers at these units were designed to burn low volatile, subbituminous coal from the Powder River Basin. Presently PSO purchases this coal from Kerr McGee, which mines the Wyodak Seam in Wyoming.

In order to investigate the impact of Croweburg Seam coal on PSO's boilers and to gather information on whether this same coal can be cleaned to decrease slagging and fouling and reduce emissions, a comprehensive testing plan was developed by the research team involved in this project.

Test Plan

The Test Plan called for Croweburg Seam coal to be physically cleaned in three different flowsheet tests so that at least one test would produce a minimum clean coal energy recovery of 86 percent. Based on the results of the flowsheet tests, one of the cleaned Croweburg Seam coals would be blended at CQ Inc. with raw Wyodak seam coal and shipped to Combustion Engineering in Windsor, Connecticut, for pilot-scale combustion tests.

These combustion tests were designed to simulate the firing properties of burning a cleaned Oklahoma and raw Wyoming blend in the Northeastern Station's boilers. Also, the information gathered from these tests would help to determine whether cleaning the Oklahoma coal would improve the overall performance of Units 3 and 4. Figure 1 illustrates the coal sources and test sites involved in the Northeastern Station testing.

Test Plan Implementation

PSO provided coal mined at Peabody Coal Company's Rogers County No. 2 mine located near Vinita, Oklahoma. The coal was surface-mined from the 12-in. to 15-in. thick Croweburg Seam. On July 17, 1990, five covered rail cars, carrying approximately 500 tons of coal directly from the mine, arrived at CQ Inc.'s Coal Quality Development Center (CQDC) in Homer City, Pennsylvania. In the following months, this coal underwent extensive flowsheet and laboratory testing.

PSO also provided the Wyodak Seam coal. Presently this coal is purchased from Kerr McGee's Jacob's Ranch Mine near Gillette, Wyoming. On September 20, 1990, two trucks carrying a total of 43 tons of Wyodak Seam coal (taken from the Northeastern Station's stockpile) were received at CQ Inc. This coal was stored and later used to produce the coal blends for combustion testing. A Coal Cleanability Characterization was also performed on this coal, although no flowsheet testing was done since this subbituminous coal is low in both ash and sulfur content.

Coal Cleanability Characterizations routinely measure the extent to which a particular coal can be cleaned through a series of laboratory and commercial-scale tests. To date, CQ Inc. has characterized the cleanability of more than 30 nationally important utility coals, including coals from 12 states and two Canadian provinces.

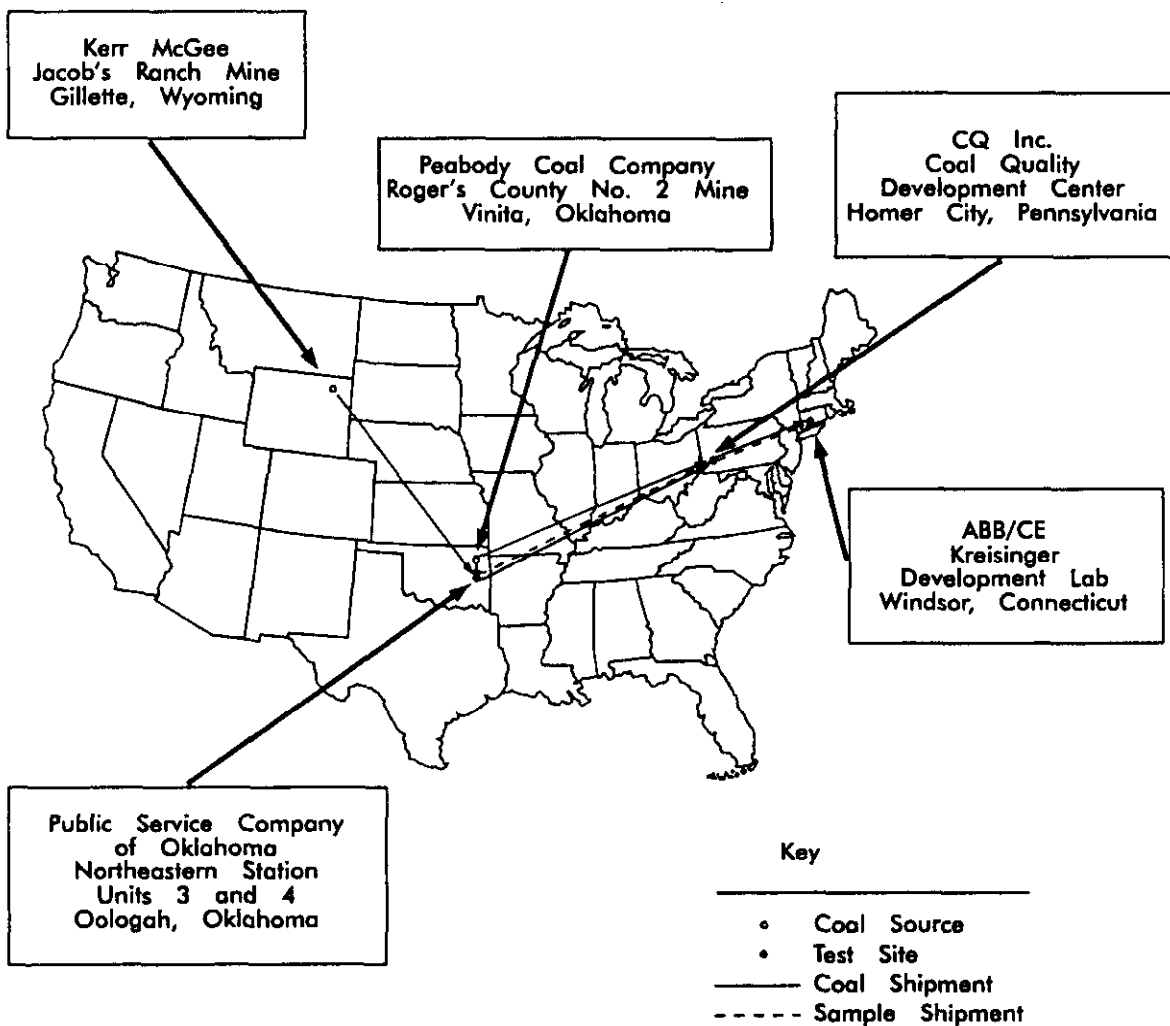


Figure 1. Coal Sources and Test Sites for Northeastern Station Plant Testing.

Specifically, a coal cleaning characterization can be divided into three main components:

- Raw-coal characterization
- Liberation studies
- Commercial-scale cleaning tests

A raw coal characterization uses extensive laboratory analyses from size and washability tests to provide general information about the quality of a raw coal. Liberation studies help determine the degree of pure coal (or mineral matter) that can be liberated by progressive crushing. Commercial-scale cleaning tests allow engineers to select and test coal cleaning devices capable of effectively and efficiently cleaning a particular coal.

Although Croweburg Seam coal had not previously been characterized at the CQDC, preliminary laboratory tests on the delivered coal indicated that it would respond well to physical cleaning techniques. Using the data gathered from these preliminary tests, CQ Inc. engineers designed a comprehensive testing schedule to evaluate the properties of the Croweburg Seam coal.

Of the three flowsheet tests performed, each one was designed to produce an improved quality clean coal, with one having a minimum 86 percent energy recovery. In order to achieve this goal, various operating parameters within the selected flowsheets were changed from test to test.

Coal Background Information

PSO purchases Croweburg Seam coal from Peabody Coal Company, Marine Coal Sales, and Patch Coal Company. At the time of testing, the preferred source was Peabody Coal Company because its operations are larger and better equipped to provide a supply of this particular fuel.

As mentioned earlier, PSO purchases the majority of its coal from Kerr McGee's Jacob's Ranch Mine located in Wyoming's Powder River Coal Basin. Additional coal seam information provided by PSO, Peabody, Kerr McGee, and the 1991 Keystone Coal Industry Manual is summarized below.

Croweburg Seam

As shown in Figure 2, Croweburg Seam coal is found in three states: Oklahoma, Kansas, and Missouri. The seam ranges in thickness from approximately 12 to 42 inches. The coal in this seam is classified as medium-high volatile bituminous with sulfur contents ranging between 0.4 percent and 10.0 percent and as-received heating values in excess of 10,000 Btu/lb. Typical uses of this coal are for steam generation and in lime and cement kilns. Table 1 shows Croweburg Seam coal production by state.

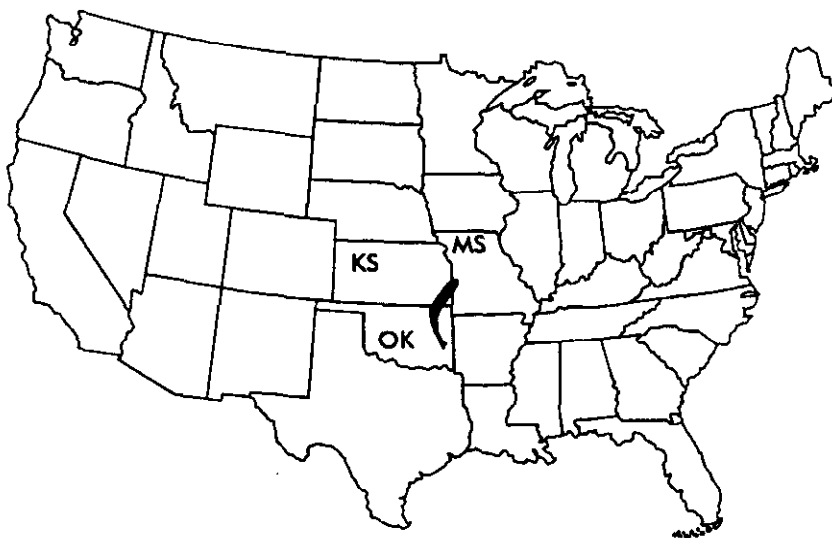


Figure 2. Croweburg Seam Coal

Table 1. Croweburg Seam Coal Production. (Tons)

<u>Year</u>	<u>Oklahoma</u>	<u>Missouri</u>	<u>Kansas</u>
1987	845,000	25,000	180,000
1988	440,000	32,000	95,000
1989	539,000	41,000	145,000
1990	Figures not yet available		

Typically, coal beds in Oklahoma are 0.8 to 10 feet thick, 0.4 percent to 6.5 percent sulfur and contain from 11,500 to 14,500 Btu's. Utility-used coal (in 1986) averaged 3.0 percent sulfur, and total coal production statewide averaged 2.5 percent sulfur. The Oklahoma Department of Mines reported 1.77 million short tons of coal produced in 1986. In 1987, with passage of the state law requiring Oklahoma power plants to burn at least 10 percent Oklahoma Coal (by Btu value), more than 50 percent of the 1.8 million tons of Oklahoma coal produced was being shipped to the Oklahoma electric utilities, Public Service Company of Oklahoma (PSO) and Oklahoma Gas and Electric Company (OG&E).

Oklahoma. In Oklahoma, most of the Croweburg Seam coal contains less than one percent sulfur (with an average of 0.6 percent) but in the southernmost region (Okfuskee County), it contains from 1.4-3.5 percent sulfur. Croweburg coal has been the leading coal produced in Oklahoma. It is high volatile A and B bituminous in rank and is generally 1 to 3.5 feet thick.

Overburden (40 to 100 feet thick) consists of a thin black shale, thick gray shale, silty sandstone, Verdigris limestone, shale, sandstone, and the Iron Post Seam coal.

In 1988 nine surface mines produced 440,855 tons of this coal. This figure is 21 percent of the state's total production of 2.12 million tons. The Croweburg Seam is mined in Craig, Rogers, Nowata, Tulsa, Okmulgee, and Wagoner counties.

In 1988, all the coal produced in Oklahoma (including the Croweburg Seam) was produced from surface mines. However, in 1989 one underground slope mine was opened in the Croweburg Seam. Since 1987 over 90 percent of all the Croweburg Seam coal produced in Oklahoma was shipped to utilities. (A specific breakdown was not available.) The remainder was sold to brokers and small lime and cement kilns. Table 2 shows a breakdown, by year, of Croweburg Seam in Oklahoma.

Table 2. Uses of Croweburg Seam Coal in Oklahoma

<u>Year</u>	<u>Production</u>	<u>Sold to Utilities</u>	<u>Other</u>
1987	845,000	765,000	80,000
1988	440,000	400,000	40,000
1989	539,000	485,000	53,000
1990	Figures not yet available		

Approximately 687 million tons of recoverable Croweburg Seam coal remains in Oklahoma. Of this total, 53 million tons are in Craig County. Croweburg coal has been known as Broken Arrow, Henrietta, and Sequoyah coal.

Missouri. Croweburg Seam coal, in Missouri, lies in the lower part of the Pennsylvanian strata and is of Middle Pennsylvanian age. It is a thin seam that is widespread and persistent. In west Missouri this seam ranges in thickness from 11 to 30 inches and is currently being surface mined in Vernon County.

As-received analyses give average values for the following parameters:

- Moisture 14.1
- Ash 8.9
- Sulfur 4.3
- Btu/lb 11,051

In north central Missouri, the Croweburg is an important reserve in six counties, where it ranges in thickness from 17 inches to 36 inches. In Henry County it is often mistakenly called the Bevier. Other names used to identify Croweburg Seam coal in Missouri are:

- One Foot
- Lower Ardmore
- Moundville
- Soadstone
- Little Tebo
- Fire Clay

Kansas. Presently, in Kansas, Croweburg coal is found in three counties: Bourbon, Cherokee, and Crawford. Total recoverable reserves of this seam are approximately 45 million tons. These reserves are found in the Southeastern Kansas Coal Field.

Overall the seam has an average thickness of 14 inches and is mined in Crawford County. A typical analysis follows:

• Moisture (Wt %)	4
• Ash (Wt %)	17
• Sulfur (Wt %)	4
• Btu/lb	12,000
• Dry Btu/lb	14,800
• Ash-softening	2,200°F

Other names used to identify this coal are:

- One Foot
- Cato
- Huntsinger
- Mud Seam
- Fire Clay

Of the total Croweburg Seam coal mined in Kansas, over 117,000 tons are produced at two mines; the rest is produced by smaller operators. The coal is predominately used in steam production.

In conclusion, Croweburg Seam coal, where it is found, averages less than eighteen inches in thickness with overburden heights up to 100 feet. Recovery of this coal in many areas is uneconomical, and often it is mined in conjunction with other seams. Its relatively high heating values make it a good fuel for lime and cement kilns and in some areas its sulfur content is low enough for it to be classified as "compliance" coal. Table 3 gives a breakdown of Croweburg Seam coal by state and the known recoverable reserves.

Table 3. Recoverable Reserves of Croweburg Seam Coal

<u>State</u>	<u>Seam Thickness (ft.)</u>	<u>Recoverable Reserves (million tons)</u>
Oklahoma	1.1-3.4	657
Missouri	1.4-3.0	256
Kansas	1.0-1.5	45

Due to the increasing development of the vast nearby Powder River Basin coal resources, it is unlikely that Croweburg Seam coal will gain further importance or make significant contributions to the energy requirements of users outside their native states.

Wyodak Seam Coal

The Wyodak Seam is one of the many seams mined in the vast Powder River Basin. As shown on the map in Figure 3, the Powder River Coal Basin is situated in northeast Wyoming and includes Campbell county and portions of Sheridan, Crook, Weston, Niobra, Converse, Natrona, and Johnson Counties. A total of eighteen mines, owned by fifteen different companies mined 142.4 million tons during 1988. This coal field also extends into the southeast portion of Montana in the counties of Big Horn, Powder River, Rosebud, Custer, and Garfield. Here five mining companies with six mines produced 38.7 million tons of coal from the Powder River Basin. This represents over ninety percent of the state's total production.

The Wyodak Seam coals produced in Wyoming and Montana are shipped primarily to utilities in the Central and Gulf states. A limited amount is used to fuel power plants in their native states.

Wyoming. In 1988, 97.5 percent of the coal mined in Wyoming was used to fuel power plants in Wyoming and eighteen other states, one of which is Oklahoma. Public Service Company of Oklahoma burns Powder River Basin coal supplied by Kerr-McGee's Jacob's Ranch Mine.

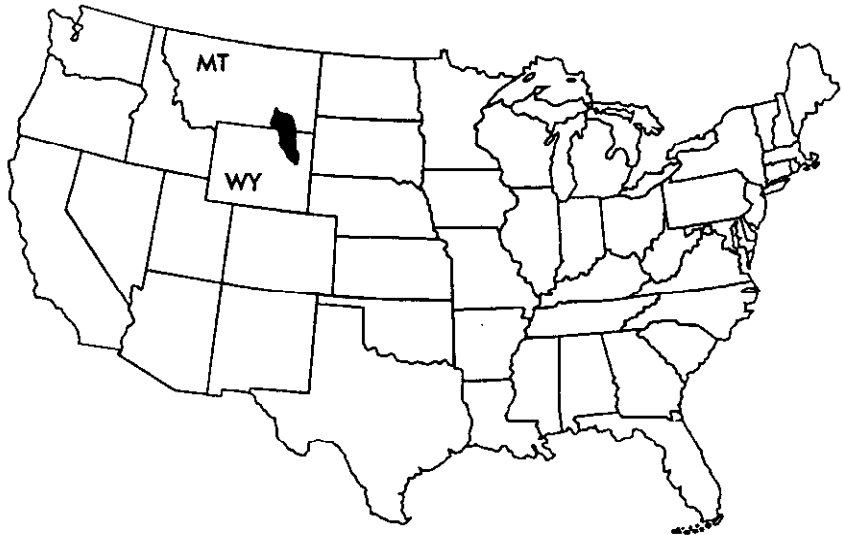


Figure 3. Wyodak Seam Coals. Powder River Basin Coal.

The Jacob's Ranch mine, located in Campbell County, mines coal from the Wyodak Seams; Upper, Middle, and Lower. Total thickness of the three seams is about sixty-five feet with approximately 150 feet of overburden. The coal produced is sub-bituminous with heating values ranging between 8,300 and 8,800 Btu's. Ash content generally falls between 4.8 and 7.7 percent with sulfur content between 0.3 and 0.8 percent. These values are typical for the Wyodak seam.

This seam is frequently 50-100 feet thick and extends for more than 100 miles along the eastern side of the Powder River Basin. This seam has been called the Wyodak-Anderson and Anderson Canyon and Smith Roland coal.

The reserve of coal that can be mined (at 19 billion tons) makes it perhaps the largest single coal bed in the United States. An average moisture-free analysis typical of most Wyodak Seam coal is summarized in Table 4.

Table 4. Typical Wyodak Seam Coal Analysis

Moisture (Wt %)	29.8
Volatile Matter (Wt %)	30.7
Fixed Carbon (Wt %)	33.5
Ash (Wt %)	6.0
Sulfur (Wt %)	0.5
Btu/lb	8,220

North of Gillette, the Wyodak Seam remains intact, but in some locations partings separate it into two or three seams. Other names for this coal are Smith Roland and Anderson Canyon. The Anderson Canyon Seam is also found in Montana.

Montana. Of the nine active mines in Montana's Powder River Basin, three of them are mining the Anderson Canyon (or Anderson) Seam. This activity accounted for 15.4 million tons in 1988 and 16.1 tons in 1989 (which is 40 percent of the state's production in 1988 and 43 percent in 1989). These figures show an increase in production in the Anderson Seam while coal production for the entire state decreased by four percent during that same period.

Approximately 99 percent of the coal mined in Montana is used for power generation, with the remaining is used for home heating. Besides Montana utilities, utilities in four other midwestern states and one southern state (Louisiana) currently purchase coal from companies mining the Anderson Seam. These midwestern states are Indiana, Michigan, Minnesota, and Wisconsin.

Analyses show a sulfur range from 0.11 to 1.63 percent, ash from 3.8 to 10.6 percent, and heating values averaging 9280 Btu/lb.

About 50 billion tons of coal that can be mined remains in the Powder River Basin. The companies presently mining the Anderson Seam hold approximately 6.3 billion tons of recoverable reserves.

RAW COAL CHARACTERISTICS

In mid-1990, approximately 500 tons of Croweburg and 40 tons of Wyodak raw coals were shipped to CQ Inc.'s Coal Quality Development Center (CQDC) in western Pennsylvania. Six-ton samples of each coal were collected at CQDC's primary sampler as each was received. These samples were sent to the laboratory where they were split into one-ton subsamples, which were used for raw-coal characterization tests. The laboratory performed the following tests on the raw coals:

- Screen Analysis
- Washability Analysis
- Head Analysis
- Trace Element Analysis

Summaries of the raw coal laboratory data are given in Tables 5 through 8. Detailed laboratory specifications and raw coal data are given in Appendix A. Analyses from these tests allow general statements to be made about the quality of the raw coals. They also allow evaluation of cleaning scenarios other than those tested at commercial scale. Summaries of the raw coal data are given in Tables 5 through 8. Detailed raw coal data are found in Appendix A.

Croweburg Seam Raw Coal Characteristics

The raw Croweburg Seam coal had a total moisture content of 9.42 percent and the following general characteristics, reported on a dry, weight percent basis:

- | | |
|--------------------------|-------|
| • Ash (Wt %) | 13.16 |
| • Volatile Matter (Wt %) | 33.76 |
| • Fixed Carbon (Wt %) | 53.08 |
| • Total Sulfur (Wt %) | 0.69 |
| • Pyritic Sulfur (Wt %) | 0.28 |

The Croweburg raw coal had a calculated dry, mineral matter-free fixed carbon value of 70, which according to ASTM classifications, places it in the medium volatile bituminous class. This is typical of Croweburg seam coal from northeastern Oklahoma.

Size Analysis

Raw coal size data are summarized in Table 6 and detailed raw coal size data are in Appendix A. This information shows that the smallest size fraction (minus 200 mesh) contains the highest percentage of ash and the lowest sulfur content. Some beneficiation of this coal can be achieved by

sizing alone. For example, removing the minus 200 mesh size fraction during cleaning reduces the ash content of the coal from 13.5 percent to 10.7 percent. Since the raw coal is low in sulfur to begin with, such removal would have little effect on total sulfur or SO₂ emissions potential.

Table 5. Raw-Coal Quality Summary. Croweburg Seam Coal (Dry Basis).

PROXIMATE ANALYSIS

Total Moisture (Wt %)	9.42
Ash (Wt %)	13.16
Volatile Matter (Wt %)	33.76
Fixed Carbon (Wt %)	53.08

Heating Value (Btu/lb) 12,672

Sulfur

Total (Wt %)	0.69
Pyritic (Wt %)	0.28
Pyritic/Total (%)	41

SO₂ (lb/MBtu) 1.09

Ash (lb/MBtu) 10.39

Hardgrove Grindability (HGI) 62

Chlorine (Wt %) 0.24

LiO₂ (Wt % in Ash) 0.01

ULTIMATE ANALYSIS

Carbon (Wt %)	71.02
Hydrogen (Wt %)	4.41
Nitrogen (Wt %)	1.50
Sulfur (Wt %)	0.69
Ash (Wt %)	13.16
Oxygen (Wt %)	9.22

SIZE DISTRIBUTION (Wt %)

+1 1/2-in.	1.5
1 1/2-in. x 3/4-in.	19.2
3/4-in x 3/8-in.	22.4
3/8-in. x 28M	44.4
28M x 100M	4.8
100M x 200M	1.4
200M x 0	6.4

Table 5. Raw-Coal Quality Summary (Continued). Croweburg Seam Coal, (Dry Basis).

ASH FUSIBILITY (°F)**(Reducing/Oxidizing)**

Initial Deformation	2064/2147
Softening	2111/2207
Hemispherical	2149/2267
Fluid	2215/2357

ASH COMPOSITION (Wt %)

SiO ₂	47.04
Al ₂ O ₃	15.69
Fe ₂ O ₃	11.24
CaO	16.51
MgO	1.32
Na ₂ O	0.64
K ₂ O	2.47
TiO ₂	0.70
MnO ₂	0.22
P ₂ O ₅	0.37
SO ₃	2.19

Ash Type	Lignitic
Slagging Index	2105 (high)
Fouling Index	0.64 (low)

Table 6. As-Received Raw Coal Size Data. Croweburg Seam Coal.

<u>Size Passed</u>	<u>Size Retained</u>	<u>Wt%</u>	<u>Ash</u>	<u>Sulfur</u>	<u>Cumulative Ash</u>
	1 1/2-in.	1.49	11.53	0.65	11.53
1 1/2-in.	3/4-in.	19.18	9.35	0.60	9.50
3/4-in.	3/8-in.	22.36	8.99	0.70	9.24
3/8-in.	28 mesh	44.36	10.70	0.70	9.98
28 mesh	100 mesh	4.79	19.26	0.79	10.46
100 mesh	200 mesh	1.42	25.63	0.83	10.69
200 mesh		6.40	54.11	0.52	13.47

**Wyodak Seam Raw Coal
Characteristics**

As shown in Tables 7 and 8, the raw Wyodak coal had a total moisture content of 31.63 percent and the following general characteristics, reported on a dry weight percent basis:

- Ash (Wt %) 6.68
- Volatile Matter (Wt %) 43.48
- Fixed Carbon (Wt %) 49.84
- Total Sulfur (Wt %) 0.54
- Pyritic Sulfur (Wt %) 0.11

The as-received Wyodak raw coal had a calculated moist, mineral matter-free Btu value of 8,782 which, according to ASTM classifications, places it in the subbituminous C class. This is typical of the Wyodak Seam and other coals from the Powder River Basin.

Size Analysis

As-received raw coal size data are summarized in Table 8 and detailed raw coal size data are in Appendix B. This information shows that the smallest size fraction (minus 200 mesh) contains the highest percentage of ash and a relatively low sulfur content. However, no real beneficiation of this coal can be achieved by sizing alone.

Table 7. Raw Coal Quality. Wyodak Seam Coal (Dry Basis).

PROXIMATE ANALYSIS

Total Moisture (Wt %)	31.63
Ash (Wt %)	6.68
Volatile Matter (Wt %)	43.48
Fixed Carbon (Wt %)	49.84
Heating Value (Btu/lb)	11,919
Sulfur	
Total (Wt %)	0.54
Pyritic (Wt %)	0.11
Pyritic/Total (%)	21
SO ₂ (lb/MBtu)	0.91
Ash (lb/MBtu)	6.68
Hardgrove Grindability (HGI)	57
Chlorine (Wt %)	0.04
LiO ₂ (Wt % in Ash)	0.01

ULTIMATE ANALYSIS

Carbon (Wt %)	68.14
Hydrogen (Wt %)	4.94
Nitrogen (Wt %)	0.92
Sulfur (Wt %)	0.54
Ash (Wt %)	6.68
Oxygen (Wt %)	18.78

SIZE DISTRIBUTION (Wt %)

+1 1/2-in.	2.69
1 1/2-in. x 3/4-in.	13.78
3/4-in x 3/8-in.	27.82
3/8-in. x 28M	45.03
28M x 100M	4.71
100M x 200M	1.31
200M x 0	4.66

Table 7. Raw Coal Quality Summary (Continued). Wyodak Seam Coal (Dry Basis).

ASH FUSIBILITY (° F)

(Reducing/Oxidizing)

Initial Deformation	1990/2170
Softening	2075/2215
Hemispherical	2079/2218
Fluid	2082/2226

ASH COMPOSITION (Wt %)

SiO ₂	32.55
Al ₂ O ₃	14.08
Fe ₂ O ₃	6.37
CaO	20.48
MgO	3.73
Na ₂ O	0.84
K ₂ O	0.49
TiO ₂	0.60
MnO ₂	0.06
P ₂ O ₅	1.25
SO ₃	17.30

Ash Type	Lignitic
Slagging Index	2105 (high)
Fouling Index	0.64 (low)

Table 8. As-Received Raw Coal Size Data. Wyodak Seam Coal.

<u>Size Passed</u>	<u>Size Retained</u>	<u>Wt%</u>	<u>Ash</u>	<u>Sulfur</u>	<u>Cumulative Ash</u>
	1 1/2-in.	2.69	6.77	0.41	6.77
1 1/2-in.	3/4-in.	13.78	5.79	0.45	5.95
3/4-in.	3/8-in.	27.82	5.87	0.50	5.90
3/8-in.	28 mesh	45.03	6.15	0.55	6.03
28 mesh	100 mesh	4.71	7.39	1.10	6.09
100 mesh	200 mesh	1.31	8.22	1.19	6.12
200 mesh		4.66	17.78	0.67	6.67

LIBERATION POTENTIAL

Physical coal cleaning processes can only separate physically discrete particles. If a single particle is composed of 50 percent coal and 50 percent mineral matter, the mineral matter must be accepted as part of the clean coal or part of the refuse. Crushing the particle to produce a number of smaller particles can change the relative composition of the new particles. If complete liberation occurs, each new particle will be composed of pure coal or pure mineral matter. However, it is not currently cost effective to crush or grind any coal fine enough for complete liberation, but increasing the degree of liberation can increase the amount of energy recovered from the raw coal during the cleaning process, thereby reducing cleaning costs. Detailed raw coal liberation data are found in Appendices C and D.

This investigation quantified the impact of progressive crushing on the Croweburg and Wyodak seam coals. In this study, various subsamples of the raw coal were crushed to topsizes of 3/4-in., 3/8-in., 28 mesh, and 100 mesh. Each subsample was then subjected to washability analyses and compared to their respective raw coals.

Croweburg Seam Coal

Figures 4, 5, and 6 depict the composite washability of all size fractions of the uncrushed Croweburg Seam coal and the same coal crushed to four different topsizes. Figure 4 shows that progressive crushing liberates sulfur, which would also lower sulfur dioxide emissions (Figure 5) while significantly increasing energy recoveries. Since this coal is already a compliance coal, the benefits achieved in lowering the SO₂ emissions potential from 1.1 down to 0.75 lbs/MBtu may not offset the energy costs associated with crushing and cleaning fine-sized. As for the ash content, illustrated in Figure 6, crushing can produce significant reductions in ash-forming mineral matter.

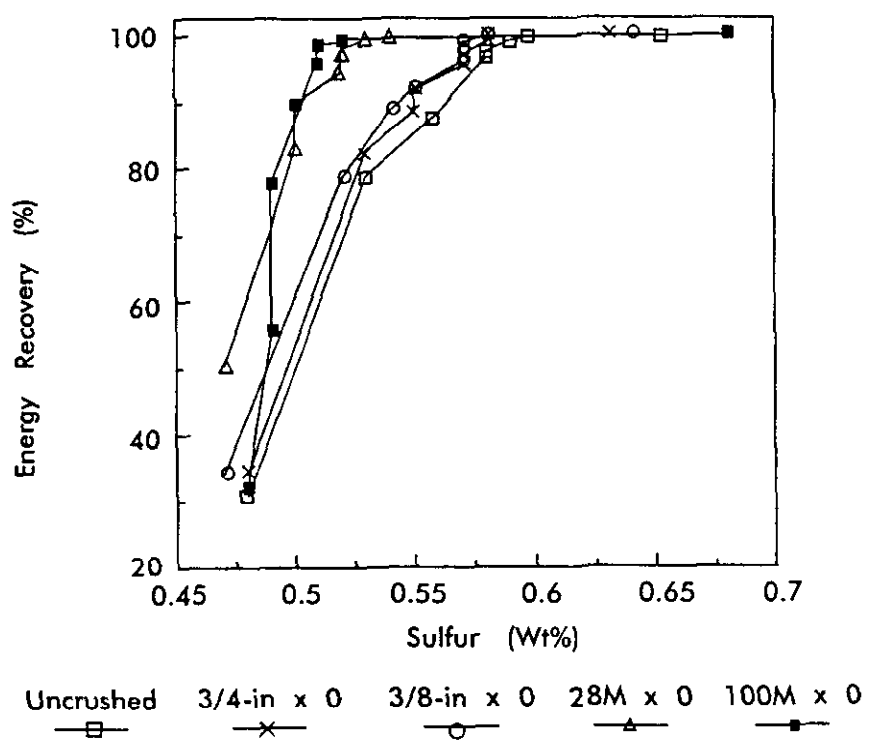


Figure 4. Liberation Potential. Croweburg Seam Coal.

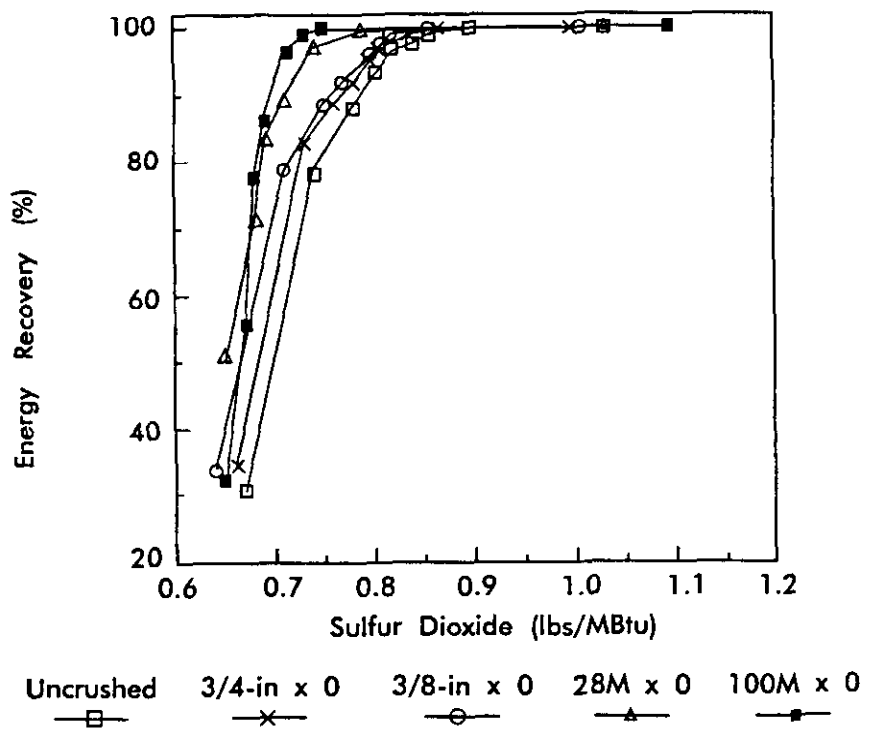


Figure 5. SO₂ Liberation Potential. Croweburg Seam Coal.

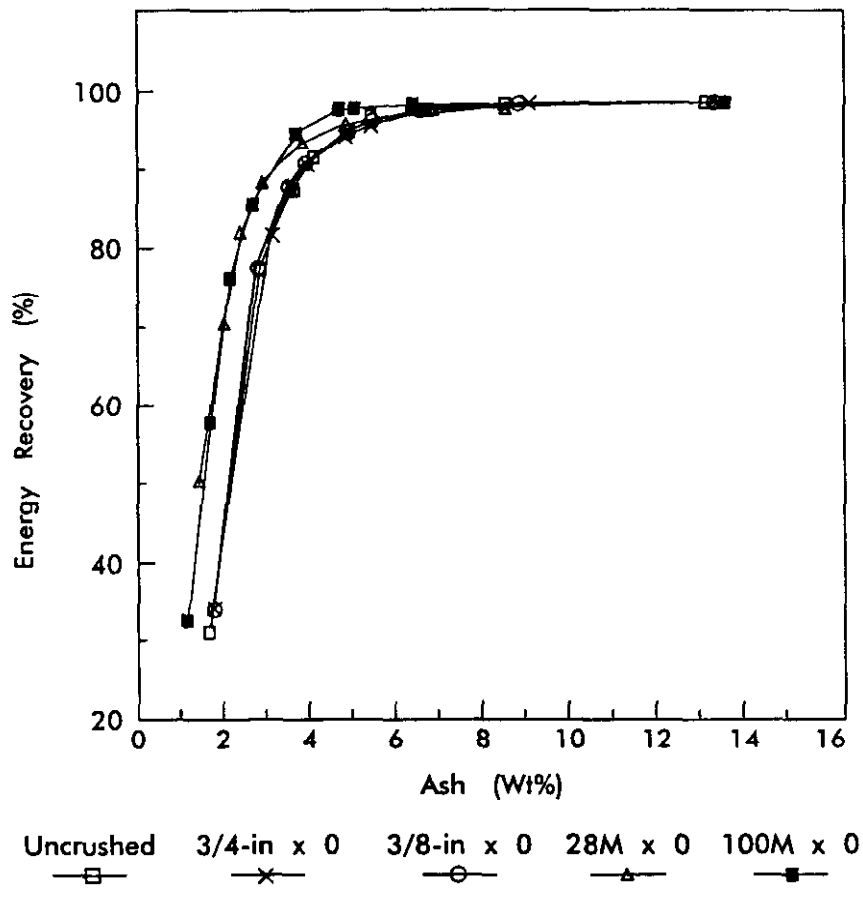


Figure 6. Ash Liberation Potential. Croweburg Seam Coal.

Wyodak Seam Coal

The liberation studies done on this coal show somewhat similar relationships to the Croweburg Seam coal between crushing and the degree of achievable liberations. As Figures 7 and 8 appear to indicate, sulfur and the resulting SO_2 emissions potential are reduced by crushing as well as providing significant ash reductions (Figure 9). However, this is probably attributable to noise in the data since there are some discrepancies between the amounts of contaminants in the various size fractions. Therefore, crushing Wyodak Seam coal to achieve ash and sulfur reductions is not likely to be effective.

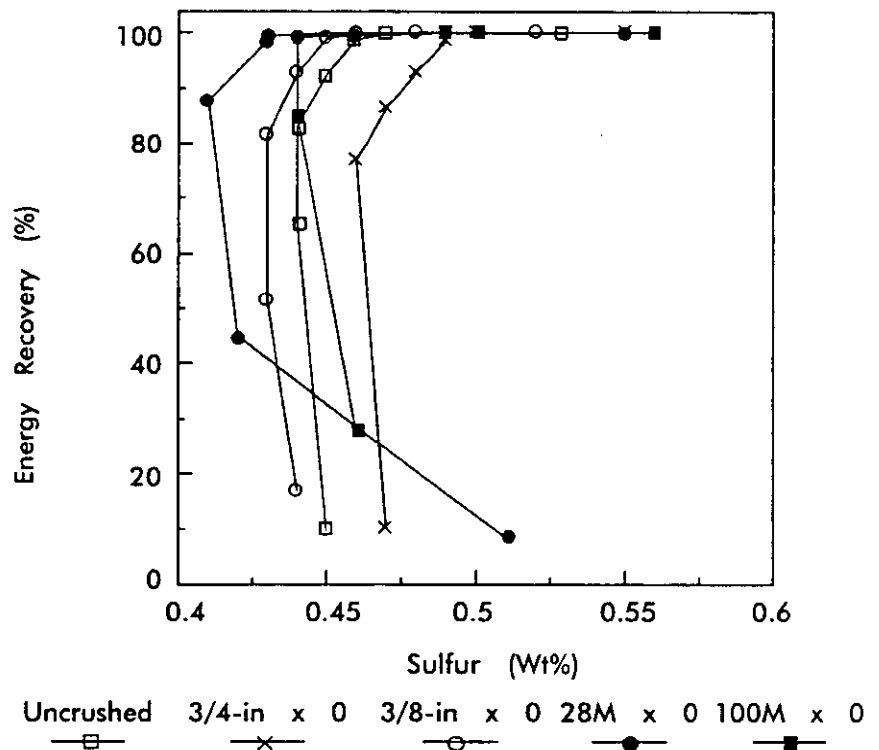


Figure 7. Sulfur Liberation Potential. Wyodak Seam Coal.

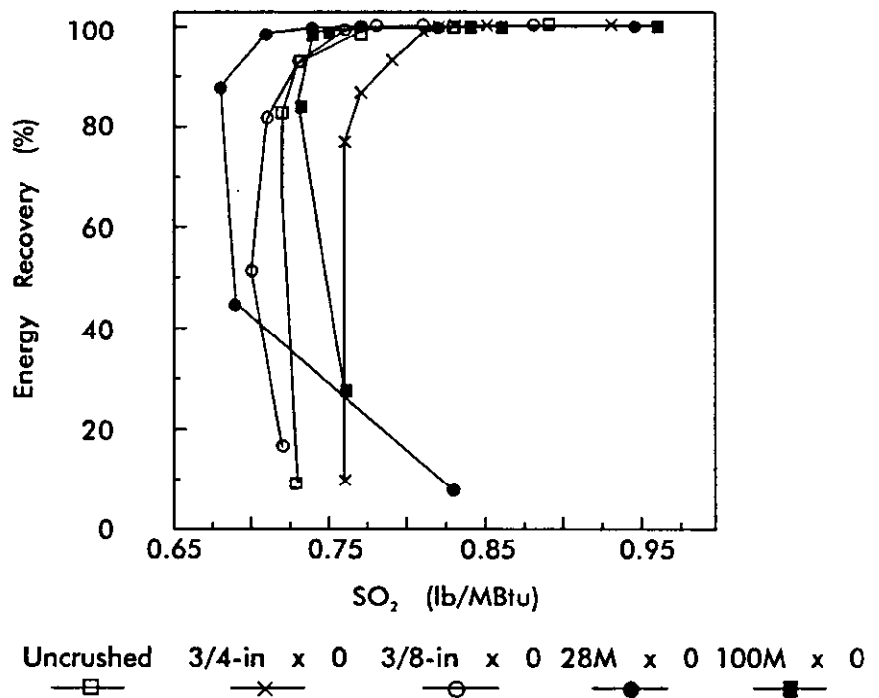


Figure 8. SO₂ Liberation Potential. Wyodak Seam Coal.

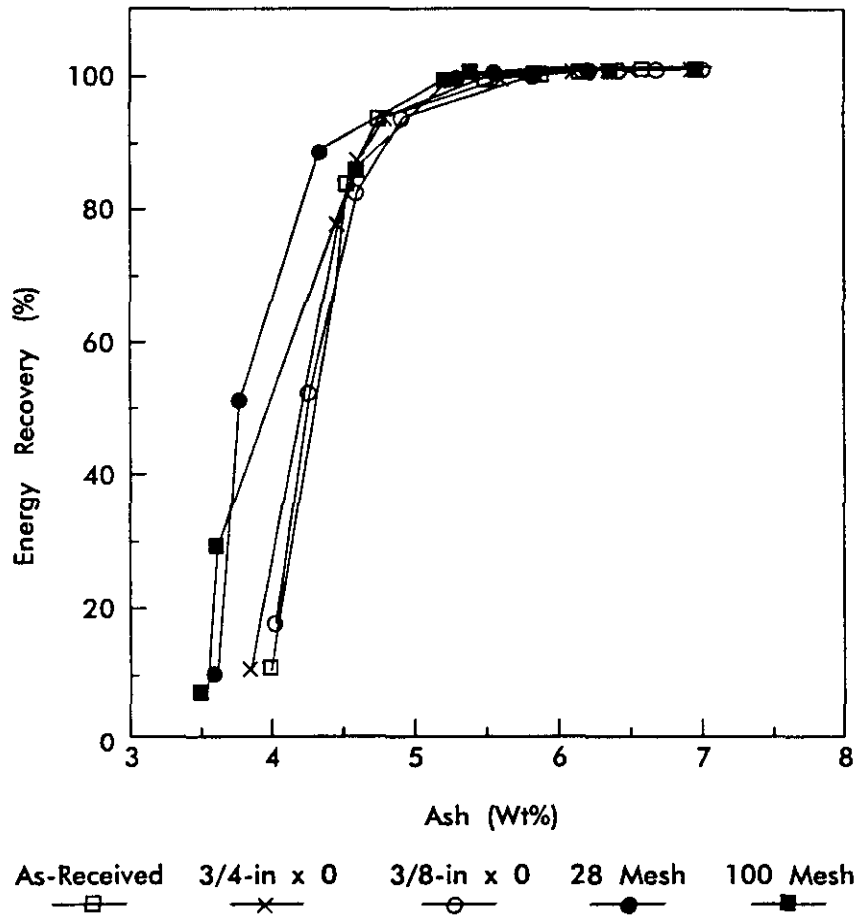


Figure 9. Ash Liberation Potential. Wyodak Seam Coal.

WASHABILITY STUDIES

A washability analysis is a laboratory float/sink test in which a sized sample of coal is placed in a series of liquids of known specific gravity. These liquids are used to partition the coal sample into a series of specific gravity fractions. Coal particles, which are relatively light, float; mineral particles, which are denser than coal, sink. These laboratory separations or washability studies are used to theoretically determine the most profitable way to clean a particular coal as well as evaluate the types of equipment to use in cleaning. The degree to which these laboratory results directly reflect the performance of commercial coal cleaning equipment depends on the equipment used, methods of operation, clean coal quality desired, and raw coal characteristics.

Raw coal liberation data can be used in washability studies to determine the degree of cleaning possible. One of the uses of cumulative float data is the evaluation of the percentage of near gravity material (the amount of feed material within plus or minus 0.1 specific gravity unit of the specific gravity of separation) in the coal. These evaluations help predict the difficulty that might be expected when making separations at certain specific gravities.

<u>Percent Near Gravity Particles</u>	<u>Difficulty in Separation</u>
0-7	Simple
7-10	Moderately Difficult
12-15	Difficult
15-20	Very Difficult
20-25	Exceedingly Difficult
Above 25	Formidable

Raw coal liberation data are also used to help determine operating parameters of cleaning processes and equipment.

Croweburg Seam Coal

Table 9 illustrates the cumulative float-sink data from the liberation studies performed on the Croweburg Seam coal. From these data it was concluded that separations at specific gravities above 1.45 would be simple, whereas those below 1.45 would be moderately difficult at best.

Table 9. Cumulative Float-Sink.

<u>Sink</u>	<u>Float</u>	<u>Wt (%)</u>
	1.250	26.58
1.250	1.300	68.81
1.300	1.350	77.93
1.350	1.400	82.10
1.400	1.450	83.16*
1.450	1.500	84.22*
1.500	1.550	85.29*
1.550	1.600	86.37
1.600	1.800	87.86
1.800	2.000	90.79
2.000	2.450	93.65
2.450		100.00

* Interpolated values

The above data were used to construct the theoretical yield curve shown in Figure 10. Line graphs such as these provide general information concerning the operation of the equipment used to clean this coal. The "knee" of the curve generally represents the economic limit for quality improvement through cleaning because the relationship between yield and quality deteriorates below this point. Using this criterion, cleaning Croweburg coal below a specific gravity of approximately 1.4 is not likely to be economical.

Another line graph, shown in Figure 11, "Energy Recovery versus Specific Gravity," indicates the approximate specific gravity where separations should occur to produce a desired energy recovery. One of the coal cleaning specifications for this program was to produce cleaned coals with a minimum of 86 percent energy recovery. The graph shows that any gravity separation above 1.40 should produce the desired coal quality.

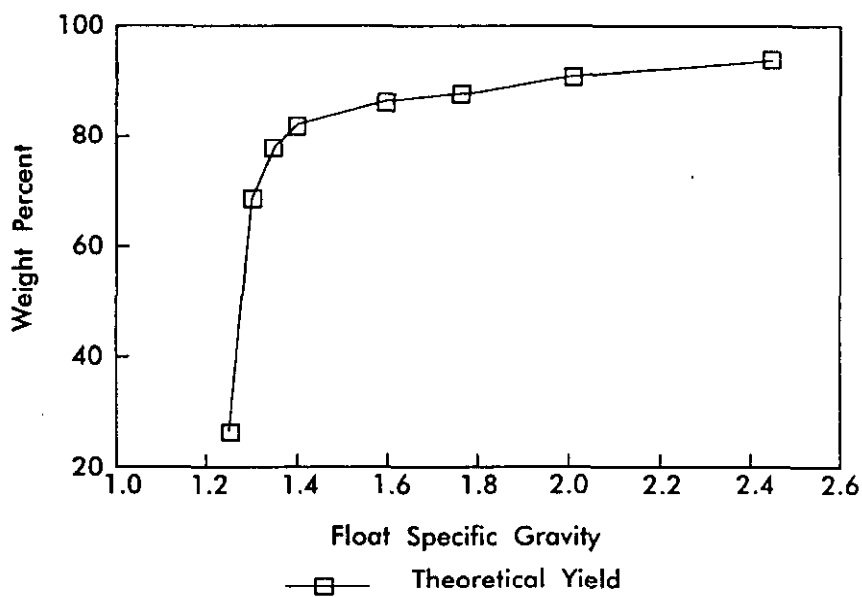


Figure 10. Theoretical Yield Curve. Croweburg Seam Coal.

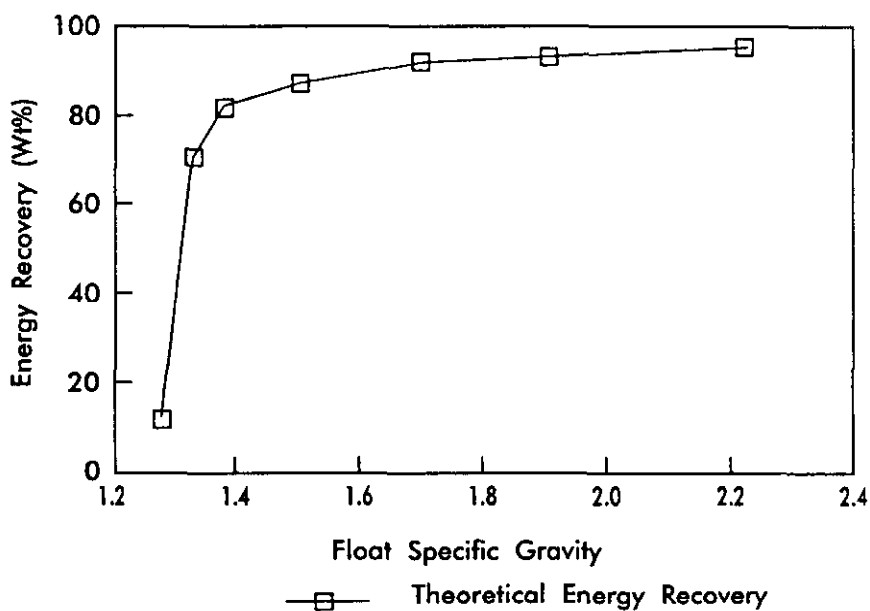


Figure 11. Theoretical Energy Recovery Curve. Croweburg Seam Coal.

In summary, the analysis of the raw coal data indicated that the Croweburg Seam coal could be physically cleaned to produce three levels of improved quality coals.

Wyodak Seam Coal

Although it was not the intent of this project to perform actual commercial-scale cleaning studies on the Wyodak Seam coal, evaluations of the potential cleanability were done. Table 10 summarizes the cumulative float-sink data for the raw Wyodak coal.

Table 10. Cumulative Float-Sink

<u>Sink</u>	<u>Float</u>	<u>Wt (%)</u>
	1.250	9.11
1.250	1.300	64.18
1.300	1.350	80.82
1.350	1.400	90.39
1.400	1.600	97.31
1.600	1.800	98.78
1.800	2.000	99.24
2.000	2.450	99.64
2.450		100.00

From this information, separations above 1.60 would be simple, while those from 1.40 to 1.60 would be moderately difficult. Theoretically, a 1.50 specific gravity separation should produce a yield in excess of 90 percent with a 90 percent energy recovery. These values were obtained from the theoretical curves illustrated by Figures 12 and 13.

This study shows that although it may not be desirable to clean Wyodak Seam coal at the present time, cleaning could be performed if it became required as part of future emission or toxic control programs or to increase thermal efficiency.

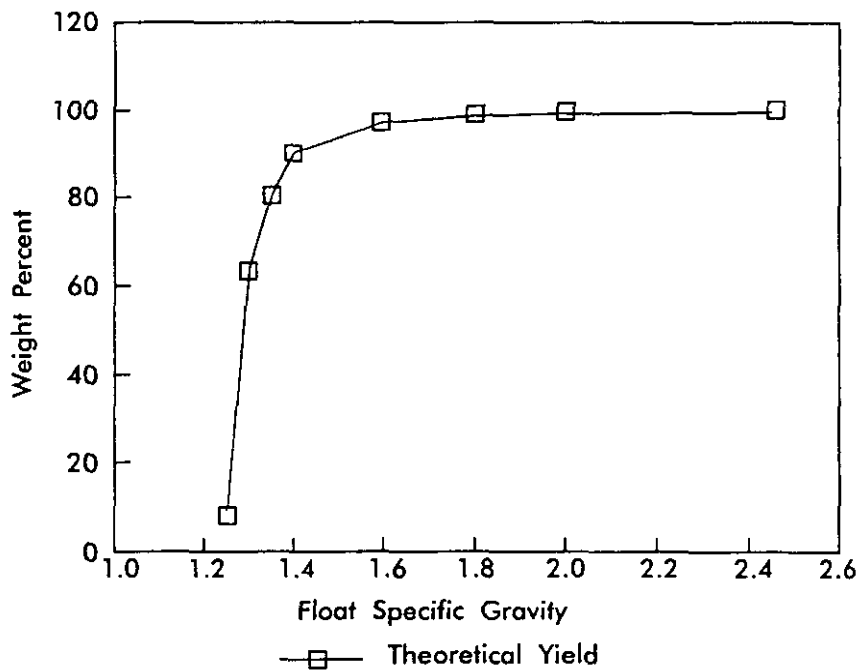


Figure 12. Theoretical Yield Curve. Wyodak Seam Coal.

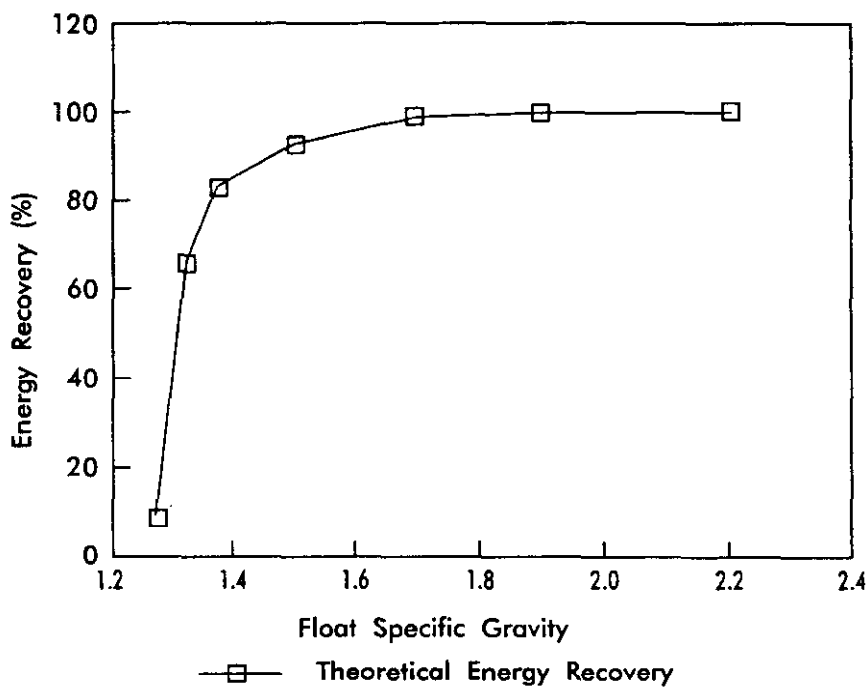


Figure 13. Theoretical Energy Recovery Curve. Wyodak Seam Coal.

COAL CLEANING EVALUATION

The Croweburg Seam coal was cleaned utilizing a flowsheet consisting of three main separating devices: heavy-media cyclones (HMC), water-only cyclones (WOC), and froth flotation cells (FF). Following a series of set-up tests, three flowsheet tests were conducted, with the circulating specific gravity of the HMC circuit varied for each test. Cyclone apex diameters, vortex finder lengths, and frother/collector dosages were also varied from test to test. Components of these flowsheets are summarized in Table 11.

Table 11. Croweburg Flowsheet Configurations

Test No.	CQ Run No.	Plant Feed	Feed Size to Cleaning Device			HMC S.G.
			HMC	WOC	FF	
1	90051901	Crushed 3/4" x 0	3/4" x 28M	28M x 0	100M x 325M	1.55
2	90051902	Crushed 3/4" x 0	3/4" x 28M	28M x 0	100M x 325M	1.40
3	90051903	Crushed 3/4" x 0	3/4" x 28M	28M x 0	100M x 325M	1.80

Figure 14 shows the HMC-WOC-FF flowsheet used for the tests. The run-of-mine coal was crushed to 3/4-in. topsize and fed to the plant at a rate of 15 tons per hour. The raw coal was fed to a double-deck, raw-coal deslime screen; the screen's top deck scalped off coal larger than 3/4-in., and the bottom deck was fitted with 0.5mm profile wire, resulting in a 28 mesh separation. The 3/4-in. x 28M coal was mixed with a heavy-medium suspension of finely-ground magnetite in water and pumped to a 14-in.-diameter Roberts & Schaefer heavy-media cyclone. Both the HMC clean coal and refuse products were drained and rinsed of medium on a combination of sieve bends and vibrating screens, and dewatered in separate basket centrifuges.

The 28M x 0 raw coal (deslimed screen underflow) was slurried and cleaned in a two-stage, middlings recirculation, water-only cyclone circuit consisting of a Krebs 10-in.-diameter primary cyclone and a Krebs 6-in.-diameter secondary cyclone. The 28M x 0 primary WOC overflow was sized at 100 mesh by a VariSieve fine coal sieve bend, with the 28M x 100M clean-coal product dewatered by a screen-bowl centrifuge and the 100M x 0 underflow routed to a froth flotation sump. This material was pumped from the flotation sump to a bank of seven 4-in.-diameter thickening cyclones and classified at a nominal size of 325 mesh. The 100M x 325M material was conditioned with frother and collector, and fed to two banks of four 21 cubic foot WEMCO froth flotation cells. The clean coal concentrate was dewatered in a screen-bowl centrifuge and then discharged onto the clean coal conveyor, along with the 28M x 100M primary WOC overflow and 3/4-in. x 28M HMC overflow products. The froth tailings, thickening cyclone overflow, and secondary WOC underflow were thickened in a static thickener, and then dewatered by a solid-bowl centrifuge. These refuse materials were subsequently discharged onto the refuse conveyor, along with the dewatered HMC underflow product.

Flowsheet Performance

Coal cleaning produced relatively high weight yields and energy recoveries for all three flowsheets (Table 12). Flowsheet 2 had a yield of 80 percent and an 89 percent energy recovery while the yield of Flowsheet 1 increased to 82 percent with an energy recovery of 91 percent. Overall, Flowsheet 3 produced the highest yield (87 percent) and the greatest energy recovery (91 percent). Note that all of the Flowsheet tests produced energy recoveries that exceeded the targeted parameter of 86 percent. Even at these high energy recoveries, significant reductions in ash and SO₂ emissions potential were obtained with all flowsheets. Flowsheet 1 reduced the ash 57 percent and the SO₂ 14 percent, Flowsheet 2 reduced the ash 67 percent and the SO₂ 19 percent, and Flowsheet 3 reduced the ash 54 percent while reducing the SO₂ 16 percent.

Appendix E gives weight-percent yields (Wt %) and tons-per-hour yields of the various components used in the three flowsheet tests.

Table 12. Flowsheet Performance

<u>Performance Parameters</u>	<u>Flowsheet 1</u>	<u>Flowsheet 2</u>	<u>Flowsheet 3</u>
Yield (Wt %, Dry)	82	80	87
Energy Recovery (%)	91	90	95
Ash Removal (Wt %)	61	71	57
Ash Reduction (%)	57	67	54
SO ₂ Reduction (%)	14	19	16

Combustion Related Laboratory Analysis

Table 13 compares important raw coal and clean coal parameters. The table shows that all three flowsheets significantly lowered the ash content of the raw coal. The raw coal ash of 10.39 lb/MBtu was lowered to 4.79 lb/MBtu by Flowsheet 1, to 3.42 lb/MBtu in Flowsheet 2, and to 4.91 lb/MBtu in Flowsheet 3. Cleaning also decreased the SO₂ emission potential of the raw Croweburg coal. From a raw coal value of 1.09 lb/MBtu, Flowsheet 1 produced an emissions potential of 0.90 lb/MBtu, Flowsheet 2 produced an SO₂ value of 0.88 lb/MBtu, and Flowsheet 3 reduced the SO₂ potential to 0.95 lb/MBtu.

As should be expected because of the significant reductions in the non-combustible mineral matter content of the raw coal, the dry heating value of the raw coal was increased from a raw coal value of 12,672 Btu/lb to 13,854 Btu/lb, 14,168 Btu/lb and 13,728 Btu/lb in Flowsheets 1 through 3, respectively.

In addition to the above commonly measured parameters of ash, sulfur, and Btu, the following additional laboratory analyses were also performed to evaluate the cleaning of Croweburg Seam coal:

- Ash composition
- Ash fusibility
- Hardgrove grindability
- Proximate analysis
- Ultimate analysis

Table 13. Raw and Clean Coal Comparisons. (Dry Basis, Except Where Noted).

	<u>Raw Coal</u>	<u>Flowsheet 1</u>	<u>Flowsheet 2</u>	<u>Flowsheet 3</u>
Ash	10.39 lb/MBtu	4.79 lb/MBtu	3.42 lb/MBtu	4.91 lb/MBtu
SO ₂	1.09 lb/MBtu	0.90 lb/MBtu	0.88 lb/MBtu	0.95 lb/MBtu

Ash Composition (Wt %) Ash Basis, SO₃ Free, Normalized to 100%

	<u>Raw Coal</u>	<u>Flowsheet 1</u>	<u>Flowsheet 2</u>	<u>Flowsheet 3</u>
SiO ₂	48.90	50.35	54.43	49.76
Al ₂ O ₃	16.31	18.93	21.37	16.37
Fe ₂ O ₃	11.68	11.78	11.40	12.52
CaO	17.16	13.43	6.29	16.13
MgO	1.37	1.45	1.65	1.34
Na ₂ O	0.67	0.52	0.56	0.36
K ₂ O	2.57	2.80	3.53	2.52
TiO ₂	0.73	0.44	0.54	0.72
MnO ₂	0.23	0.18	0.10	0.22
P ₂ O ₅	0.39	0.12	0.11	0.07
<hr/>				
Total	100.00	100.00	100.00	100.00

Ash Fusion Temperatures (°F) (Reducing/Oxidizing)

	<u>Raw Coal</u>	<u>Flowsheet 1</u>	<u>Flowsheet 2</u>	<u>Flowsheet 3</u>
Initial				
Deformation	2064/2147	2068/2254	2164/2289	2091/2121
Softening	2111/2207	2163/2293	2233/2331	2118/2178
Hemispherical	2149/2267	2191/2348	2283/2425	2136/2197
Fluid	2215/2357	2218/2382	2422/2510	2160/2291

Table 13. Raw and Clean Coal Comparisons (Continued). (Dry Basis, Except Where Noted).

Hardgrove Grindability Index (HGI) at Stated Residual Moisture

	<u>Raw Coal</u>	<u>Flowsheet 1</u>	<u>Flowsheet 2</u>	<u>Flowsheet 3</u>
	62 @ 3.08	57 @ 3.91	58 @ 4.30	56 @ 3.91
Heating Value (Dry, Btu/lb)	12,672	13,854	14,168	13,728

Proximate Analysis (Wt %)

	<u>Raw Coal</u>	<u>Flowsheet 1</u>	<u>Flowsheet 2</u>	<u>Flowsheet 3</u>
Ash	13.16	6.63	4.84	6.74
Volatile Matter	33.76	35.16	37.53	35.49
Fixed Carbon	53.08	58.21	57.63	57.77
Sulfur				
Total	0.69	0.62	0.62	0.65
Sulfate	0.01	0.01	0.01	0.02
Pyritic	0.28	0.17	0.13	0.18

Ultimate Analysis (Wt %)

Carbon	71.02	68.18	79.39	76.75
Hydrogen	4.41	4.91	5.06	4.90
Nitrogen	1.50	1.95	1.91	1.71
Sulfur	0.69	0.62	0.62	0.65
Oxygen	9.22	7.45	8.18	9.25

This information may be useful to boiler operators and provides insight into the change in the coal's combustion characteristics with cleaning.

Ash Composition. Coal cleaning can affect ash composition, potentially changing the behavior of ash in the boiler. As Table 13 also shows, coal cleaning significantly changed the weight percent (Wt %) of most of the ash constituents. Calcium oxide decreased from a raw coal value of 17.16 percent to as low as 6.29 percent in Flowsheet 2; sodium

oxide was lowered from 0.67 percent in the raw coal to 0.36 percent in Flowsheet 3; phosphorous oxide decreased from 0.39 percent in the raw coal to 0.07 percent in Flowsheet 3; and titanium oxide was lowered from 0.73 percent in the raw coal to 0.54 percent in Flowsheet 2. However, the concentrations of iron oxide, was increased from 11.68 percent to as high as 12.52 percent in Flowsheet 3.

Overall, Flowsheet 2 caused significant increases in the concentrations of aluminum oxide (from 16.37 to 21.37 percent), silicon oxide (from 48.90 to 54.43 percent), magnesium oxide (from 1.37 to 1.65 percent), and potassium oxide (from 2.57 to 3.53 percent).

Of particular interest to power generating companies such as PSO are the concentrations of sodium and potassium in the ash of coal since, in sufficient quantity, these elements may contribute to boiler fouling problems. The CQ Inc. commercial-scale cleaning tests significantly reduced the concentration of sodium in the ash of all of the cleaned coals. However, the concentration of potassium was increased in two of the three flowsheet tests.

Overall, as illustrated by Figures 15 and 16, Flowsheet 3 produced more reductions of ash constituents than the other flowsheets. All three tests produced significant reductions in many of the ash constituents, but only Flowsheet 2 (which used the lowest specific gravity of separation) altered its ash composition enough to change the ash's slagging classification from a lignitic type ash to an Eastern type ash.

Ash Fusibility. Of the reported ash fusibility data, the initial deformation and fluid temperatures are usually of primary concern. The initial deformation temperatures and the fluid temperatures of the ash of the raw coal were not changed significantly by the cleaning done in Flowsheets 1 and 3. There were, however, important increases in all ash fusibility temperatures achieved by Flowsheet 2.

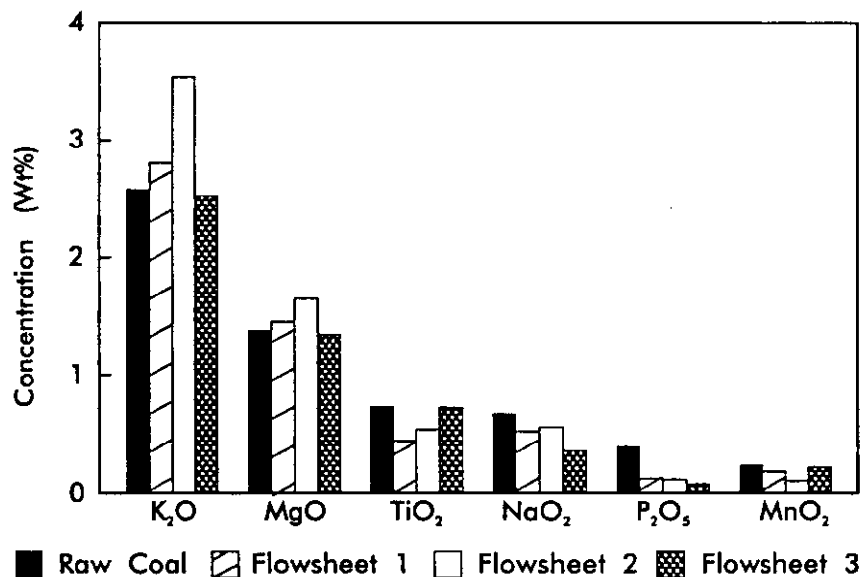


Figure 15. Ash Composition. Croweburg Seam Coal.
SO₂ Free Basis.

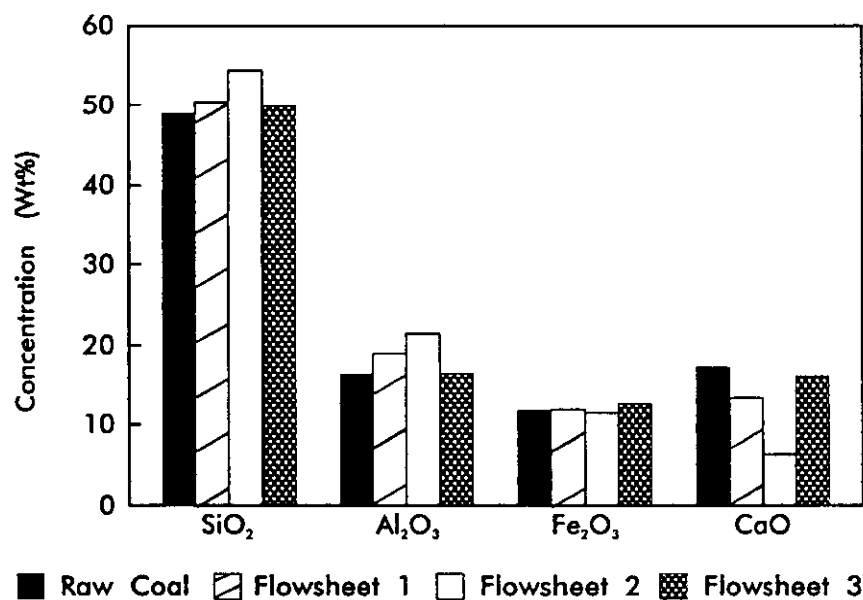


Figure 16. Ash Composition. Croweburg Seam Coal.
SO₂ Free Basis.

Initial deformation temperatures increased from 2064 °F (reducing atmosphere) and 2147 °F (oxidizing atmosphere) in the raw coal to 2164 °F (reducing) and 2289 °F (oxidizing) in the clean coal. Also increased by Flowsheet 2 were the fluid temperatures (both reducing and oxidizing atmospheres) from 2215 °F and 2357 °F in the raw coal to 2422 °F and 2510 °F in the cleaned coal. The "Low" fouling index classification assigned to the ash of Flowsheet 2 signifies that this clean coal ash will be less likely than the raw coal ash to flow in streams or drip from heat-absorption surfaces or form heavy clinkers on the grates under a fuel bed.

Hardgrove Grindability. Coal cleaning may, at times, adversely change the grindability of the coal. The Hardgrove Grindability Index (HGI) results determined for the cleaned coals (57, 58, and 56) are lower than those measured for the raw coal (62). Cleaning, therefore, makes the coal somewhat harder to grind. However, the reduction of pyrites from 0.28 percent in the raw coal to 0.17 percent, 0.13 percent, and 0.18 percent in the cleaned coals should improve pulverizer performance slightly. Also, the increased heating value resulting from cleaning will offset to some degree the increased grinding energy that may be needed by the pulverizers.

Proximate Analysis. A proximate analysis helps characterize how a coal reacts when it is heated; that is how much of the coal goes off as gas and vapors (volatile matter) and the quantity that remains as fixed carbon. Also, a proximate analysis usually quantifies the amount of ash and sulfur in the ash. Cleaning significantly decreased ash content in all three flowsheets.

Ash decreased from a raw coal value of 13.6 percent to 6.6 percent in Flowsheet 1, to 4.8 percent in Flowsheet 2, and to 6.7 percent in Flowsheet 3. Total sulfur of 0.69 percent in the raw coal was decreased to 0.62 percent in Flowsheets 1 and 2, and 0.65 percent in Flowsheet 3. Volatile matter was increased from 33.8 percent in the raw coal to 35.2 percent in Flowsheet 1, 37.5 percent in Flowsheet 2, and 35.5 percent in Flowsheet 3. Fixed carbon was also increased in all three flowsheet tests--from 53.1 percent in the raw coal to 58.1 percent in Flowsheet 1, 57.6 percent in Flowsheet 2, and 57.8 percent in Flowsheet 3.

Ultimate Analysis. Among other things, an ultimate analysis summarizes the organic constituents of a coal and is a convenient and uniform method of comparing coals. An ultimate analysis also is required by boiler operators for computing boiler air requirements, heat losses, and weight of the products of combustion. As with the proximate analysis, cleaning produced some significant changes.

The weight percent of carbon increased for the coals of Flowsheets 2 and 3--from 71.0 percent in the raw Croweburg coal to 79.4 percent in the coal of Flowsheet 2 and 76.8 percent in the coal of Flowsheet 3. However, it decreased to 68.2 percent in Flowsheet 1. The hydrogen content was increased from 4.4 percent in the raw coal to 4.9 percent in Flowsheets 1 and 3, and 5.1 percent in Flowsheet 2. Nitrogen also increased from a raw coal value of 1.5 percent to 2.0 percent, 1.9 percent, and 1.7 percent in Flowsheets 1 through 3, respectively. Only oxygen was significantly decreased by cleaning--from 9.2 percent in the raw coal to 7.5 percent in Flowsheet 1 and 8.2 percent in Flowsheet 2. Flowsheet 3 had a slight increase to 9.3 percent. Note that a decrease in oxygen content signifies an increase in the heating potential of the coal.

Trace Elements

No new constraints on trace element emissions were placed on the power generation industry under the 1990 Clean Air Act. However, it is expected that new regulations will be forthcoming following the Federally mandated three-year study period. Because of the uncertainty of the full effects of any new laws, a portion of this coal characterization study focused on determining whether certain trace elements could be removed by physical coal cleaning processes.

As with any coal, the Croweburg Seam coal's inorganic constituents are primarily made up of clay, rock, and shale. Some of the inorganics are inherent but the majority of the inorganic mineral matter is extraneous and can be associated with the coal seam itself and may end up included with the coal because of the mining operation. Minerals frequently found in coal are:

- Silicates
- Oxides

- Sulfides
- Sulfates
- Carbonates

A number of studies have found that specific elements in a coal can be associated with the inorganic mineral matter. Trace elements will have specific mineral associations rather than occurring sporadically throughout all forms of mineral matter in coal. For example, arsenic, mercury, and nickel have been found to have a close relationship with pyrite. On the other hand, trace elements have been found in mineral forms such as cinnabar (mercury), galena (lead), or millerite (nickel) where they are a major portion of the mineral structure. Also, many of the mineral forms in which trace elements occur are sulfides. However, trace element-bearing minerals may also be entrapped within the coal itself and as progressively smaller particle sizes are considered, the likelihood of the mineral occurring as a separate particle increases.

Although it is not fully understood how the different compounds and their mineral constituents are transformed during processing and combustion, it has been shown that certain of these elements (when found in the atmosphere) can sometimes be attributed to man-made sources such as coal-fired power generation. Conventional coal cleaning techniques that are effective in removing mineral matter from coal will also be effective in removing certain trace elements because of those elements' affinity for specific mineral matter.

Conventional coal cleaning using gravity separation of coarse coal fractions can be effective because they are proven methods of removing major mineral matter forms such as clays, rocks, and shales. Coal cleaning methods that involve deep cleaning of the fine coal fractions can also increase mineral matter liberation and therefore can be used to reduce associated trace elements. But as mineral matter is liberated, individual particles may react to the cleaning process differently. For example, sulfides may float in a flotation cell and carry associated metals with them into the clean coal.

The flowsheet tests performed on the raw Croweburg Seam coal indicate that cleaning can alter its trace element concentrations. As Table 14 and Figure 17 show, in almost every case trace elements were removed during cleaning. However, the concentration of fluorine was increased by 25 percent in Flowsheet 1 and mercury increased by 58 percent in Flowsheets 2 and 33 percent in Flowsheet 3.

Table 14. Trace Elements (ppm)

<u>Element</u>	<u>Raw Coal</u>	<u>FS1</u>	<u>FS2</u>	<u>FS3</u>
Fluorine	43.6	58.4	46.2	41.3
Chromium	18.3	7.69	10.2	9.93
Nickel	30.9	27.5	28.4	27.9
Zinc	88.1	19.5	17.3	25.8
Arsenic	4.13	3.50	3.63	2.50
Selenium	1.68	1.57	1.29	0.84
Silver	0.02	0.01	0.02	0.006
Cadmium	0.29	0.04	0.02	0.08
Barium	57.2	9.61	3.41	13.3
Mercury	0.08	0.06	0.12	0.19
Lead	10.9	8.24	7.1	6.2

A closer look at the specific gravities of separation of the three flowsheet runs show that separating at a gravity of 1.4 (Flowsheet 2) resulted in the greatest reductions of zinc, barium, and cadmium. The reduction of these elements appear to be ash related as Flowsheet 2 also removed the most ash. Flowsheet 1, which used a 1.55 specific gravity, removed the most chromium and nickel and was the only flowsheet to lower the concentration of mercury. Overall, of the three flowsheet tests, Flowsheet 3 performed the best in reducing the most individual trace element concentrations of the raw coal. Separating at 1.80 specific gravity in Flowsheet 3 removed fluorine and the greatest amounts of arsenic, selenium, silver, and lead.

In recent years, considerable research by EPRI and other organizations has attempted to characterize the mobilization of elements in coal, its combustion gases, and ash residues.

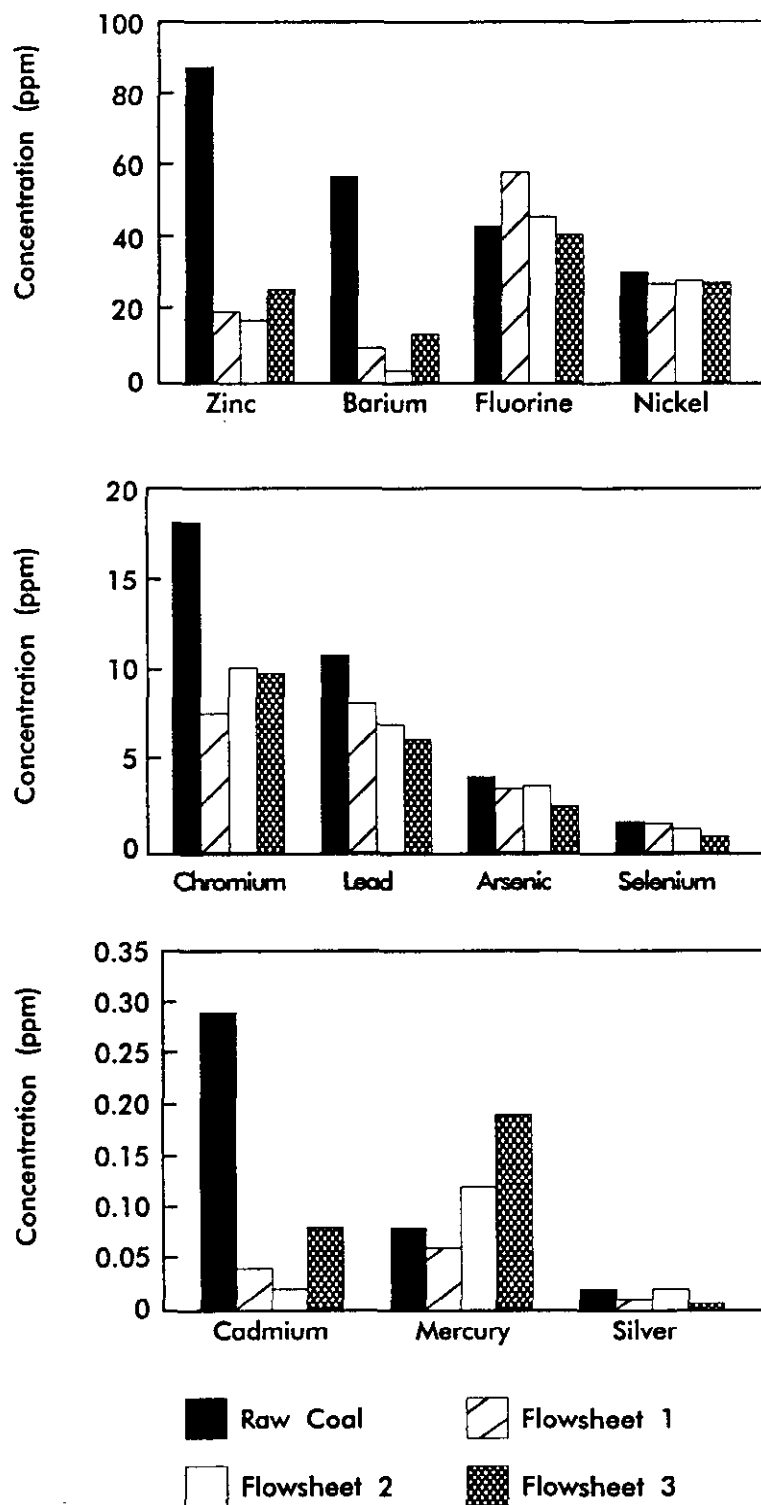


Figure 17. Trace Element Concentrations. Croweburg Seam Coal.

Some physical and chemical characteristics of the ash and flue gases are directly related to the composition of the parent coal. Coal combustion can alter the chemical composition in such a manner that certain chemicals can be dissolved and mobilized into the ash residues or gases. Of the elements studied during these tests, arsenic and selenium are associated with power plant ash fractions that are highly soluble. Volatile elements such as mercury can be found in the gases. A better understanding of the mobility of trace elements in coal cleaning residues will help determine whether or not it is environmentally advantageous to remove trace elements before combustion.

As this study shows, significant reduction of specific elements can be achieved by using conventional coal cleaning techniques. However, as also indicated by this study, continued research relating to refining existing coal cleaning techniques to remove specific trace elements is needed.

Coal Blending

Overall, Flowsheet 2 produced the best quality clean coal when considering the major clean coal parameters of heating value, ash fusion temperatures, ash reduction, and SO₂ emissions potential. Based on these criteria, the clean Croweburg coal (Clean Coal 2) produced by Flowsheet 2 was selected for blending with the raw Wyodak Seam coal for pilot-scale testing at the Kreisinger Laboratory in Windsor, Connecticut.

Wyodak/Croweburg Coal Blending

As indicated earlier, one of the objectives of the CQE project is to gather data and to correlate this data to actual power plant performance. PSO was interested in determining how much of an effect its use of blended Wyodak and Croweburg seam coals had on the boiler performance at its Northeastern Station's Units 3 and 4. Since PSO is mandated to burn a minimum of 10 percent Oklahoma coal, project engineers determined that a 90 percent Wyodak and 10 percent Croweburg coal blend was the best blend ratio for initial pilot-scale combustion testing.

Prior to the actual preparation of the coal blend to be used in the pilot-scale testing, three bench-scale blends (using a ratio of 90 percent raw Wyodak seam coal and 10 percent each of the cleaned Croweburg coals) were made and analyzed at the Homer City Coal Laboratory in Homer City, Pennsylvania. As previous clean coal data, Table 15,

Table 15. Blend Comparisons

	<u>Blend 1</u>	<u>Blend 2</u>	<u>Blend 3</u>
PROXIMATE ANALYSIS (Wt %)			
Total Moisture	27.37	27.42	27.31
Ash	7.02	6.67	7.03
Volatile Matter	44.39	43.09	45.35
Fixed Carbon	48.59	50.24	47.62
Heating Value (Btu/lb)	12,197	12,239	12,203
Sulfur			
Total (Wt %)	0.61	0.61	0.61
Pyritic (Wt %)	0.08	0.11	0.10
Pyritic/Total (%)	13	18	16
SO ₂ (lb/MBtu)	1.00	1.00	1.00
Ash (lb/MBtu)	5.76	5.45	5.76
Hardgrove Grindability (HGI)	56	55	56
Chlorine (Wt %)	0.03	0.03	0.03
LiO ₂ (Wt % in Ash)	0.02	0.02	0.02
ULTIMATE ANALYSIS (Wt %)			
Carbon	68.64	68.94	68.76
Hydrogen	5.06	5.10	5.10
Nitrogen	1.14	1.09	0.98
Sulfur	0.61	0.61	0.61
Ash	7.02	6.67	7.03
Oxygen	17.53	17.59	17.52
ASH FUSIBILITY (°F)			
(Reducing/Oxidizing)			
Initial Deformation	2100/2113	2039/2137	2096/2121
Softening	2128/2207	2121/2208	2119/2200
Hemispherical	2134/2211	2131/2212	2124/2205
Fluid	2159/2230	2137/2240	2135/2207

Table 15. Blend Comparisons (Continued)

	<u>Blend 1</u>	<u>Blend 2</u>	<u>Blend 3</u>
ASH COMPOSITION (Wt %)			
SiO ₂	32.06	32.14	30.93
Al ₂ O ₃	17.08	17.01	16.20
Fe ₂ O ₃	7.14	6.99	7.27
CaO	20.97	18.80	19.42
MgO	4.08	3.84	3.89
Na ₂ O	0.63	0.60	0.65
K ₂ O	0.79	0.76	0.71
TiO ₂	1.06	1.24	1.22
MnO ₂	0.04	0.04	0.06
P ₂ O ₅	1.01	1.05	1.01
SO ₃	16.80	17.30	16.88
ASH TYPE			
Slagging Index	Lignitic	Lignitic	Lignitic
Classification	2122	2074	2118
Fouling Index	(High)	(Severe)	(High)
Classification	0.63	0.60	0.65
	(Low-to-Medium)	(Low-to-Medium)	(Low-to-Medium)

and Figures 18 and 19 clearly show, the coal produced by Flowsheet 2 was of a significantly higher quality than those produced by the other two flowsheets, but the laboratory tests indicated that blending 10 percent of any of the cleaned coals with 90 percent of the raw Wyodak coal apparently neutralized the effects of cleaning. While most of the laboratory analyses done on the three blends produced very similar results for all three blends one important discovery was made. Blending such a small amount of cleaned Croweburg coal with the raw Wyodak coal would probably have little effect on overall boiler performance. In fact, the results indicate that burning this blend ratio would be equivalent to burning the raw Wyodak seam coal alone.

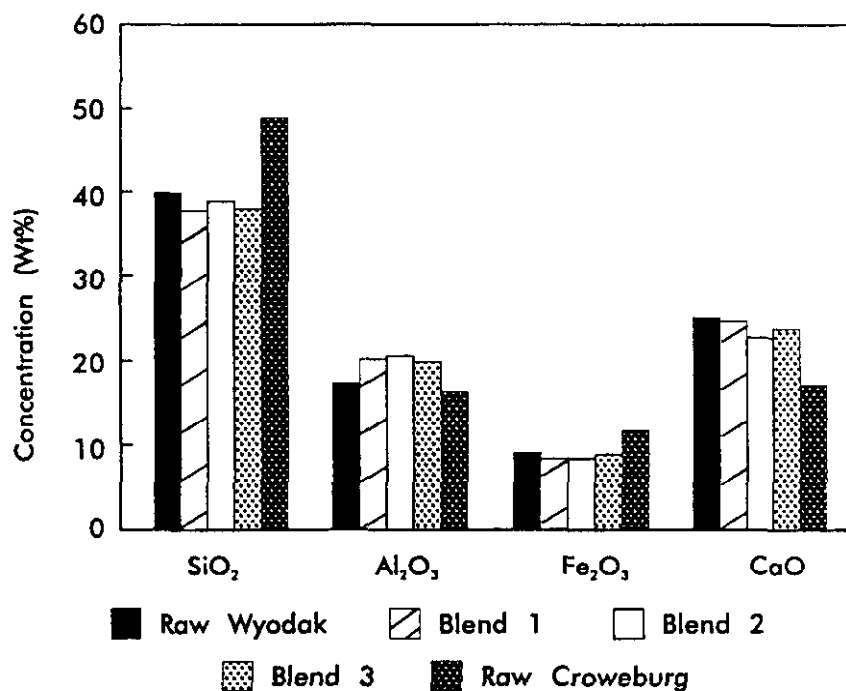


Figure 18. Raw and Clean Coal Blend Comparisons. Ash Composition, Wyodak and Croweburg Seam Coal, SO₂ Free Basis.

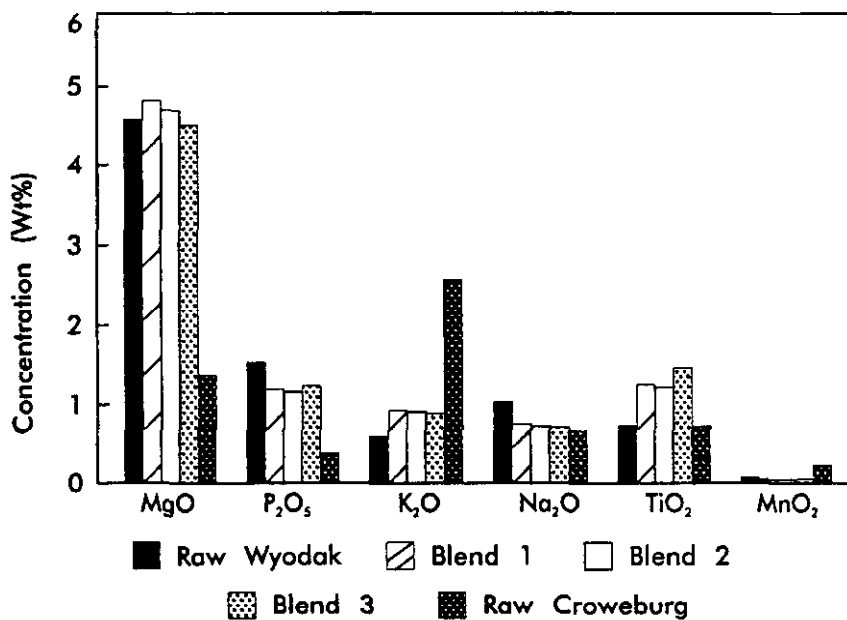


Figure 19. Raw and Clean Coal Blend Comparisons. Ash Composition, Wyodak and Croweburg Seam Coal, SO₂ Free Basis.

These laboratory results were confirmed when similar tests were performed on a composite sample of raw Wyodak and raw Croweburg seam coal gathered at the Northeastern Station during field testing and a sample of the clean Croweburg and raw Wyodak blend shipped to the Kreisinger Laboratory for pilot-scale combustion testing.

Twenty tons of 90 percent raw Wyodak and 10 percent Croweburg (on a Btu basis) were prepared at CQ Inc. and shipped by covered truck to the Kreisinger Laboratory. A sub-sample of this blend, gathered during processing, was sent to the Homer City Coal Laboratory for analysis. Table 16 and Figures 20 and 21 represent the results of those laboratory tests and those previously performed on the raw Wyodak and cleaned Croweburg coals.

As was the case with the laboratory-produced blends, these results show a close similarity in coal quality and ash composition between the raw Wyodak coal and the 90/10 blended using cleaned Croweburg coal. However, a 117°F increase in heating value was produced by the blended coal (12,036°F) when compared to the raw Wyodak coal (11,919°F).

As mentioned earlier, PSO is mandated by law to burn a minimum of 10 percent Oklahoma coal and does so by burning a blend of raw Wyodak and raw Croweburg Seam coals. The percentage of raw Croweburg blended generally ranges between 10 and 30 percent. In order to evaluate the effects of burning the blended coals, field tests were also conducted to provide boiler performance data. As part of these field tests, composite samples of the coal fired during testing were gathered (at the Northeastern Station) over a 14 day period and analyzed at the Homer City Coal Laboratory. Table 17 provides a comparison of the 90/10 composite raw coal actually burned and the 90/10 clean coal blend produced at CQ Inc.

Table 16. Comparisons of Raw Wyodak, Clean Croweburg, and 90/10 Blend

	Wyodak (Raw)	Croweburg (Clean)	90/10 Blend
PROXIMATE ANALYSIS (Wt %)			
Total Moisture	28.94	16.05	28.31
Ash	6.67	4.84	6.88
Volatile Matter	41.69	37.53	42.01
Fixed Carbon	51.64	57.63	51.11
Heating Value (Btu/lb)	11,919	14,168	12,036
Sulfur			
Total (Wt %)	0.56	0.62	0.56
Pyritic (Wt %)	0.11	0.13	0.12
Pyritic/Total (%)	20	21	21
SO ₂ (lb/MBtu)	0.94	0.88	0.93
Ash (lb/MBtu)	5.60	3.42	5.72
Hardgrove Grindability (HGI)	57	58	55
Chlorine (Wt %)	nm	0.25	nr
LiO ₂ (Wt % in Ash)	0.01	0.01	0.01
ULTIMATE ANALYSIS (Wt %)			
Carbon	67.76	79.39	68.14
Hydrogen	4.90	5.06	4.91
Nitrogen	1.10	1.91	1.04
Sulfur	0.56	0.62	0.56
Ash	6.67	4.84	6.88
Oxygen	19.01	8.18	17.47
ASH FUSIBILITY (° F)			
(Reducing/Oxidizing)			
Initial Deformation	1955/2209	2164/2289	1980/2230
Softening	2073/2239	2233/2331	2091/2234
Hemispherical	2075/2243	2283/2425	2095/2245
Fluid	2082/2248	2422/2510	2103/2253

Table 16. Comparisons of Raw Wyodak, Clean Croweburg, and 90/10 Blend (Continued)

	Wyodak (Raw)	Croweburg (Clean)	90/10 Blend
ASH COMPOSITION (Wt %)			
SiO ₂	35.90	53.00	34.08
Al ₂ O ₃	16.38	20.81	13.75
Fe ₂ O ₃	7.24	11.10	7.29
CaO	18.35	6.13	18.61
MgO	3.31	1.61	3.45
Na ₂ O	0.71	0.55	1.05
K ₂ O	0.61	3.44	0.66
TiO ₂	0.64	0.53	1.03
MnO ₂	0.07	0.10	0.05
P ₂ O ₅	0.87	0.11	1.04
SO ₃	15.08	2.92	16.70
ASH TYPE			
Slagging Index	Lignitic	Eastern	Lignitic
Classification	2013 (Severe)	0.19 (Low)	2033 (Severe)
Fouling Index	0.71	0.17	1.05
Classification	(Low-to-Medium)	(Low)	(Low-to-Medium)

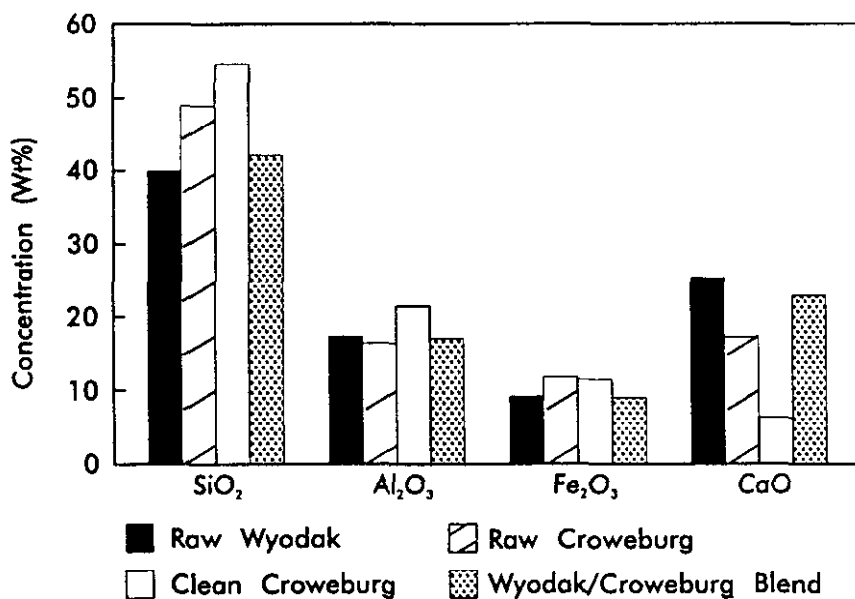


Figure 20. Raw, Clean Coal and Blend Comparisons. Ash Composition, Wyodak and Croweburg Seam Coal, SO₂ Free Basis.

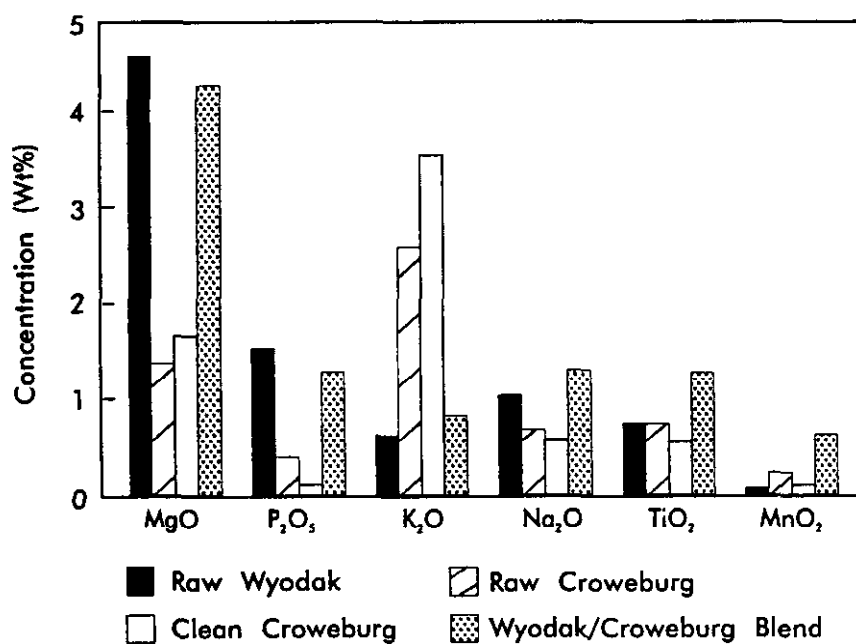


Figure 21. Raw and Clean Coal Blend Comparisons. Ash Composition, Wyodak and Croweburg Seam Coal, SO₂ Free Basis.

Table 17. Comparisons of Raw Coal Blend and Clean Coal Blend

	<u>Raw Coal Blend</u>	<u>Clean Coal Blend</u>
PROXIMATE ANALYSIS (Wt %)		
Total Moisture	26.85	28.31
Ash	6.68	6.88
Volatile Matter	42.60	42.01
Fixed Carbon	50.72	51.11
Heating Value (Btu/lb)	12,035	12,036
Sulfur		
Total (Wt %)	0.62	0.56
Pyritic (Wt %)	nr	0.12
Pyritic/Total (%)	nr	21
SO ₂ (lb/MBtu)	1.03	0.93
Ash (lb/MBtu)	5.55	5.72
Hardgrove Grindability (HGI)	52	55
Chlorine (Wt %)	0.06	nr
LiO ₂ (Wt % in Ash)	0.01	0.01
ULTIMATE ANALYSIS (Wt %)		
Carbon	68.13	69.14
Hydrogen	4.98	4.91
Nitrogen	0.63	1.04
Sulfur	0.62	0.56
Ash	6.68	6.88
Oxygen	18.96	17.47
ASH FUSIBILITY (°F)		
(Reducing/Oxidizing)		
Initial Deformation	2133/2119	1980/2230
Softening	2194/2252	2091/2243
Hemispherical	2200/2266	2095/2245
Fluid	2203/2274	2103/2253

Table 17. Comparisons of Raw Coal Blend and Clean Coal Blend (Continued)

	<u>Raw Coal Blend</u>	<u>Clean Coal Blend</u>
ASH COMPOSITION (Wt %)		
SiO ₂	31.98	34.08
Al ₂ O ₃	12.35	13.75
Fe ₂ O ₃	7.32	7.29
CaO	23.70	18.61
MgO	4.50	3.45
Na ₂ O	0.66	1.05
K ₂ O	0.68	0.66
TiO ₂	0.68	1.03
MnO ₂	0.06	0.05
P ₂ O ₅	1.18	1.04
SO ₃	17.10	16.70
ASH TYPE		
Slagging Index	Lignitic	Lignitic
Classification	2148	2033
Fouling Index	(High)	(Severe)
Classification	0.66	1.05
	(Low-to-Medium)	(Low-to-Medium)

These results show that the only notable difference between the two blended coals' qualities and ash compositions are the higher silica oxide content of the clean coal blend (34.08 percent) compared to the raw coal blend value of 31.98 percent and the lower calcium oxide content of the clean coal blend (18.61 percent) compared to the raw coal blend value of 23.70 percent. Also, the clean coal blend has a "Severe" slagging classification while the raw coal blend is classified "High".

Because the results of the pilot-scale combustion tests done at Combustion Engineering's Kreisinger Laboratory indicated that the 90 percent raw Wyodak/10 percent cleaned Croweburg blend exhibited performance characteristics similar to firing 100 percent raw Wyodak Seam coal and one of the objects of the project was to determine if cleaning the Croweburg Seam coal would

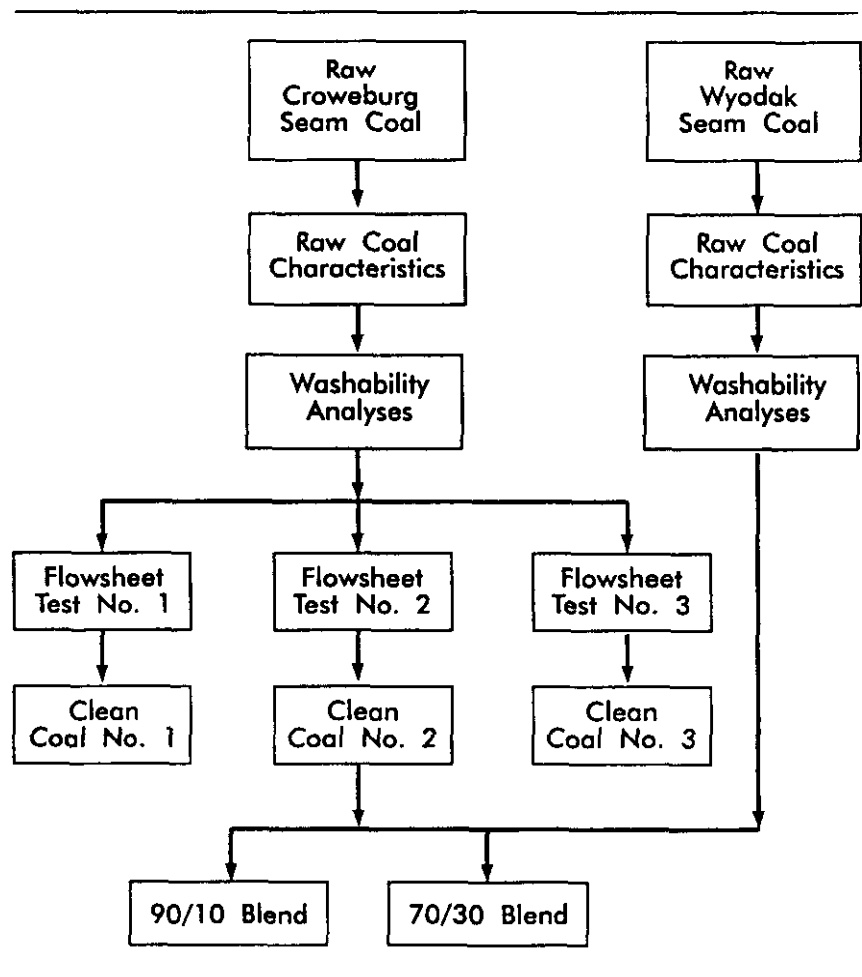
improve boiler performance, the project research team decided to produce an additional blend using 70 percent raw Wyodak Seam coal and 30 percent clean Croweburg Seam coal for pilot-scale combustion testing.

Additional cleaned Croweburg Seam coal produced from the Flowsheet 2 cleaning test was shipped to the Kreisinger Laboratory to be blended with the original 90/10 blend to produce the desired 70/30 blend. Preliminary pilot-scale tests results indicate that the 70/30 blend should provide improved boiler performance. These results, and those of the other pilot-scale combustion tests pertaining to the Northeastern testing are contained in the report "Developing the Coal Quality Expert: Pilot Scale Testing of Coals Used Under CQE's Test Program at PSO's Northeastern Unit No. 4" by Combustion Engineering.

CONCLUSIONS

This study has shown that the Croweburg Seam coal responded well to physical coal cleaning techniques and significant quality improvements were obtained within the 86 percent energy recoveries prescribed by the project team. This study also has shown that, should the need arise, the Wyodak Seam coal could also be cleaned to an improved quality.

The CQ Inc. tests show that conventional coal cleaning devices, such as jigs, spirals, and water-only cyclones, can significantly improve the overall quality of the Croweburg Seam coal and could also be used to upgrade the Wyodak Seam coal. These tests also have shown that the more advanced coal cleaning methods such as heavy-medium cyclones and froth flotation can be used to remove specific contaminants and improve the overall quality of the Croweburg Seam coal.



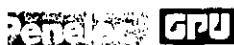
Cleaning the Croweburg coal produced yields over 80 percent while significantly improving the coal quality. For example, ash was reduced from 13.2 percent to as low as 4.8 percent and the heating value was raised from 12,672 Btu/lb to as high as 14,168 Btu/lb. Although this coal is already a compliance coal and cleaning does little to improve the overall SO₂ emissions potential, removing a large portion of the non-combustible mineral matter significantly improves the ash fusion temperatures. Also, since non-combustible mineral matter adds to the transportation costs, cleaning the Croweburg Seam coal could reduce these costs by lowering the mineral matter, thereby reducing the coal tonnages that are shipped to the power plant. In addition, there is some indication that crushing before cleaning could liberate additional ash-forming mineral matter, potentially improving the performance of the cleaning process.

Another improvement in the quality of Croweburg Seam coal as a result of cleaning is reduction of the concentrations of many trace elements of environmental concern. For example, barium was reduced from a raw coal concentration of 57 parts-per-million to as low as 3.4 parts-per-million and zinc was reduced from 88 parts-per-million to as low as 17 parts per million. However, the concentration of mercury (on a PPM basis) was doubled by cleaning.

Of particular interest to Public Service Company of Oklahoma was the extent that coal cleaning could possibly improve boiler performance problems such as slagging and fouling. This study has shown that while the quality of the Croweburg Seam coal was significantly improved by cleaning, blending it with a high percentage of raw Wyodak Seam coal may negate the gains associated with the cleaning process. However, there is evidence to show that by increasing the amount of cleaned Croweburg Seam coal to 30 percent, significant boiler performance improvements are possible.

APPENDIX A

Croweburg Seam Raw Coal Size Data



Certificate of Analysis

WASHABILITY ANALYSIS

Pennsylvania Electric Company
Homer City Laboratory



Description:
CROWEBURG RAW COAL/LIBERATION
RUN #90051909
41001 AS RECEIVED RAW COAL

Lab No.: 900700471
From: CG INC
Sampled: / /
Gross Wt.: 5668.5000 Kg

SIZE IN mm		DIRECT					CUMULATIVE RETAINED				
TESTED	RETAIN	WT %	ASH	SULFUR	BTU/LB	SO2/MBTU	WT %	ASH	SULFUR	BTU/LB	SO2/MBTU
7.500	37.500	1.49	11.53	0.65	13072	1.00	1.49	11.53	0.65	13072	1.00
9.000	19.000	19.18	9.35	0.60	13472	0.89	20.67	9.51	0.60	13443	0.89
9.500	9.500	22.36	8.99	0.70	13508	1.04	43.03	9.24	0.65	13477	0.97
9.500	0.600	44.36	10.70	0.70	13100	1.07	87.39	9.98	0.68	13286	1.02
0.600	0.150	4.79	19.26	0.79	11063	1.42	92.18	10.46	0.68	13170	1.04
0.150	0.075	1.42	25.63	0.83	10369	1.60	93.60	10.65	0.69	13128	1.05
0.075		6.40	54.11	0.52	6229	1.66	100.00	13.47	0.68	12686	1.07

Results reported on Dry
Basis and normalized to 100%
Screen sizes are square hole, Tyler
mesh unless designated otherwise.

Page 1 of 5 Approved: *Don Gibson*

Date: SEP 28 1990

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October 22, 1990

P.O. Box 29
Homer City, PA 15748
412-479-9011



Certificate of Analysis

Pennsylvania Electric Company
Homer City Laboratory



Description:
CROWEBURG RAW COAL/LIBERATION
RUN #90051909
41001 AS RECEIVED RAW COAL

Lab No.: 900700471
From: CG INC
Sampled: / /
Gross Wt.: 5668.5000 Kg

FLOAT/SINK OF PLUS BY 19.000 mm FRACTION REPRESENTING 20.67 % OF THE TOTAL SAMPLE

GRAVITY		DIRECT					CUMULATIVE FLOAT				
SINK	FLOAT	WT %	ASH	SULFUR	BTU/LB	SO2/MBTU	WT %	ASH	SULFUR	BTU/LB	SO2/MBTU
	1.250	3.26	1.56	0.47	14774	0.63	3.26	1.56	0.47	14774	0.63
.250	1.300	68.45	3.79	0.54	14338	0.75	71.71	3.69	0.53	14358	0.74
.300	1.350	14.22	10.27	0.70	13191	1.07	85.93	4.78	0.56	14165	0.79
.350	1.400	5.49	14.66	0.71	12327	1.15	91.42	5.37	0.57	14055	0.81
.400	1.600	3.51	22.14	0.74	10773	1.38	94.93	5.99	0.58	13933	0.83
.600	1.800	0.76	32.93	0.94	10575	1.78	95.70	6.21	0.58	13906	0.83
.800	2.000	0.48	39.21	3.71	2375	31.26	96.18	6.37	0.60	13848	0.86
.000	2.450	1.54	76.54	3.57	2274	31.37	97.72	7.48	0.64	13666	0.94
.450		2.28	89.48	0.66	352	37.53	100.00	9.35	0.64	13362	0.96

Pennsylvania Electric Company
Homer City Laboratory

Certificate of Analysis



Description:
CROWESBURG RAW COAL/LIBERATION
RUN #90051900
41001 AS RECEIVED RAW COAL

Lab No.: 900700471
From: CG INC
Sampled: / /
Gross Wt.: 5668.5000 Kg

FLOAT/SINK OF 19.000 BY 0.600 mm FRACTION REPRESENTING 66.72 % OF THE TOTAL SAMPLE

GRAVITY		-----DIRECT-----					-----CUMULATIVE FLOAT-----				
SINK	FLOAT	WT %	ASH	SULFUR	BTU/LB	SO2/MBTU	WT %	ASH	SULFUR	BTU/LB	SO2/MBTU
	1.250	36.39	1.74	0.48	14467	0.66	36.39	1.74	0.48	14467	0.66
.250	1.300	39.06	3.66	0.57	14247	0.80	75.45	2.74	0.53	14353	0.74
.300	1.350	8.65	8.75	0.77	13425	1.14	84.10	3.35	0.55	14257	0.77
.350	1.400	3.92	13.92	0.63	12621	1.32	88.03	3.82	0.56	14164	0.80
.400	1.600	3.86	23.19	0.87	10984	1.59	91.89	4.64	0.58	14050	0.82
.600	1.800	0.95	35.74	1.53	8226	3.73	92.84	4.96	0.59	13991	0.84
.800	2.000	0.66	41.51	1.88	5365	5.91	93.50	5.21	0.60	13937	0.86
.000	2.450	1.66	73.72	1.25	2087	11.94	95.16	6.41	0.61	13729	0.89
.450		4.84	77.28	1.44	201	143.17	100.00	9.84	0.65	13075	0.99

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Homer City Laboratory

Certificate of Analysis

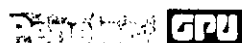


Description:
CROWESBURG RAW COAL/LIBERATION
RUN #90051900
41001 AS RECEIVED RAW COAL

Lab No.: 900700471
From: CG INC
Sampled: / /
Gross Wt.: 5668.5000 Kg

FLOAT/SINK OF 0.600 BY 0.150 mm FRACTION REPRESENTING 4.79 % OF THE TOTAL SAMPLE

GRAVITY		-----DIRECT-----					-----CUMULATIVE FLOAT-----				
SINK	FLOAT	WT %	ASH	SULFUR	BTU/LB	SO2/MBTU	WT %	ASH	SULFUR	BTU/LB	SO2/MBTU
	1.250	27.97	0.80	0.55	14554	0.76	27.97	0.80	0.55	14554	0.76
.250	1.300	34.32	2.28	0.60	14428	0.83	62.29	1.62	0.58	14485	0.80
.300	1.350	3.46	5.29	0.72	13971	1.03	65.75	1.81	0.59	14458	0.81
.350	1.400	5.06	7.97	0.72	13478	1.06	70.81	2.25	0.60	14387	0.83
.400	1.600	4.13	17.53	0.89	11607	1.54	74.94	3.09	0.61	14234	0.86
.600	1.800	1.92	32.95	1.16	9322	3.49	76.86	3.84	0.63	14112	0.89
.800	2.000	1.03	44.89	1.33	6907	3.85	77.89	4.38	0.64	14016	0.91
.000	2.450	2.60	63.86	1.23	2739	9.01	80.49	6.30	0.65	13652	0.96
.450		19.51	70.97	1.52	35	865.37	100.00	18.92	0.82	10995	1.50



Certificate of Analysis

Pennsylvania Electric Company
Homer City Laboratory



Description:
CROWBURG RAW COAL/LIBERATION
RUN #90051900
41001 AS RECEIVED RAW COAL

Lab No.: 900700471
From: CG INC
Sampled: / /
Gross Wt.: 5668.5000 Kg

FLOAT/SINK OF 0.150 BY 0.075 mm FRACTION REPRESENTING 1.42 % OF THE TOTAL SAMPLE

GRAVITY		DIRECT					CUMULATIVE FLOAT				
SINK	FLOAT	WT %	ASH	SULFUR	BTU/LB	SO2/MBTU	WT %	ASH	SULFUR	BTU/LB	SO2/MBTU
	1.250	20.09	1.10	0.55	14460	0.76	20.09	1.10	0.55	14460	0.76
.250	1.300	26.83	2.59	0.55	14293	0.77	46.92	1.95	0.55	14364	0.77
.300	1.350	10.85	3.77	0.60	14056	0.86	57.77	2.29	0.56	14307	0.78
.350	1.400	7.28	7.43	0.63	13571	0.92	65.05	2.87	0.57	14224	0.90
.400	1.600	5.25	15.05	0.74	12530	1.18	70.32	3.78	0.58	14098	0.82
.600	1.800	1.99	25.34	0.76	10666	1.43	72.31	4.38	0.59	14003	0.84
.800	2.000	1.00	46.19	1.21	6833	3.52	73.31	4.95	0.59	13905	0.86
.000	2.450	2.97	66.14	1.07	2659	8.07	75.38	6.68	0.61	13596	0.89
.450		24.62	83.50	1.20	26	917.62	100.00	25.60	0.75	10255	1.47

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Homer City Laboratory

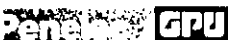


Description:
CROWBURG RAW COAL/LIBERATION
RUN #90051900
41001 AS RECEIVED RAW COAL

Lab No.: 900700471
From: CG INC
Sampled: / /
Gross Wt.: 5668.5000 Kg

FLOAT/SINK OF 0.075 BY 0.000 mm FRACTION REPRESENTING 6.40 % OF THE TOTAL SAMPLE

GRAVITY		DIRECT					CUMULATIVE FLOAT				
SINK	FLOAT	WT %	ASH	SULFUR	BTU/LB	SO2/MBTU	WT %	ASH	SULFUR	BTU/LB	SO2/MBTU
	1.250		0.00	0.00	0	0.00					
.250	1.300		0.00	0.00	0	0.00					
.300	1.350	1.25	7.09	0.50	13635	0.73	1.25	7.09	0.50	13635	0.73
.350	1.400	1.19	8.64	0.48	12810	0.74	2.44	7.85	0.49	13231	0.74
.400	1.600	10.80	15.58	0.41	12174	0.67	13.24	14.40	0.42	12369	0.68
.600	1.800	9.16	27.66	0.31	10476	0.59	22.40	19.82	0.37	11595	0.64
.800	2.000	36.24	45.07	0.30	7521	0.79	58.64	35.43	0.33	9077	0.72
.000	2.450	19.98	66.02	0.35	4664	1.72	78.61	43.20	0.33	7803	0.85
.450		21.39	88.38	0.96	537	35.55	100.00	52.86	0.47	6245	1.49



Certificate of Analysis

Pennsylvania Electric Company
Homer City Laboratory

Description:
CROWEBURG RAW COAL/LIBERATION
RUN #90051900
41001 AS RECEIVED RAW COAL

Lab No.: 900700471
From: CQ INC
Sampled: / /
Gross Wt.: 5668.5000 Kg

COMPOSITE WASHABILITY ANALYSIS OF FLUS BY 0.000 mm MATERIAL

GRAVITY		---DIRECT---					---CUMULATIVE FLOAT---				
SINK	FLOAT	WT %	ASH	SULFUR	BTU/LB	SO ₂ /MBTU	WT %	ASH	SULFUR	BTU/LB	SO ₂ /MBTU
1.250	1.250	26.58	1.68	0.48	14479	0.67	26.58	1.68	0.48	14479	0.67
1.250	1.300	42.23	3.64	0.56	14285	0.79	68.81	2.86	0.53	14360	0.74
1.300	1.350	9.11	9.07	0.74	13372	1.11	77.93	3.61	0.56	14244	0.78
1.350	1.400	4.18	13.52	0.78	12618	1.24	82.10	4.11	0.57	14162	0.80
1.400	1.500	4.27	21.43	0.77	11197	1.38	86.37	4.97	0.58	14015	0.82
1.500	1.600	1.51	31.91	0.95	9469	2.01	87.88	5.43	0.58	13938	0.84
1.600	2.000	2.90	44.34	0.67	7156	1.80	90.79	6.68	0.59	13719	0.86
2.000	2.450	2.86	76.15	1.10	3525	7.27	93.65	8.62	0.60	13393	0.90
2.450		6.65	79.58	1.28	250	11.74	100.00	13.15	0.65	12558	1.03

Page 7 of 8

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October 22, 1993

P.O. Box 29
Homer City, PA 15748
412-479-9011

Certificate of Analysis

Pennsylvania Electric Company
Homer City Laboratory

Description:
CROWEBURG RAW COAL/LIBERATION
RUN #90051900
41001 AS RECEIVED RAW COAL

Lab No.: 900700471
From: CQ INC
Sampled: / /
Gross Wt.: 5668.5000 Kg

COMPOSITE SIZE DISTRIBUTION ANALYSIS

SIZE IN mm		---DIRECT---					---CUMULATIVE RETAINED---				
ASSESSED	RETAIN	WT %	ASH	SULFUR	BTU/LB	SO ₂ /MBTU	WT %	ASH	SULFUR	BTU/LB	SO ₂ /MBTU
	19.000	20.67	9.35	0.64	13362	0.96	20.67	9.35	0.64	13362	0.96
19.000	0.600	66.72	9.84	0.65	13075	0.99	87.39	9.72	0.65	13143	0.98
0.600	0.150	4.79	18.92	0.82	10995	1.50	92.18	10.20	0.66	13031	1.01
0.150	0.075	1.42	25.60	0.75	10255	1.47	93.60	10.44	0.66	12989	1.01
0.075		6.40	52.86	0.47	6249	1.49	100.00	13.15	0.65	12558	1.03

APPENDIX B

Wyodak Seams Raw Coal Size Data



Certificate of Analysis
USABILITY ANALYSIS

Pennsylvania Electric Company
Homer City Laboratory



Description:
WYOMING-WYODAK SEAMS #90082400
RAW COAL LIBERATION
41001 AS RECEIVED RAW COAL

Lab No.: 901100014
From: CQ INC
Sampled: 09/25/90
Gross Wt.: 5205.2000 Kg

SIZE IN mm		DIRECT					CUMULATIVE RETAINED				
TESTED	RETAIN	WT %	ASH	SULFUR	BTU/LB	SO2/MBTU	WT %	ASH	SULFUR	BTU/LB	SO2/MBTU
	37.500	2.64	6.77	0.41	11937	0.69	2.64	6.77	0.41	11937	0.69
7.500	19.000	13.78	5.79	0.45	12101	0.74	16.47	5.95	0.44	12075	0.73
9.000	9.500	27.82	5.87	0.50	12074	0.82	44.29	5.90	0.48	12074	0.79
9.500	0.600	45.03	6.15	0.55	11977	0.85	89.32	6.03	0.51	12025	0.85
0.600	0.150	4.71	7.39	1.10	11786	1.27	94.03	6.09	0.54	12013	0.90
0.150	0.075	1.31	8.22	1.19	11538	2.07	95.34	6.12	0.55	12007	0.91
0.075		4.66	17.70	0.67	10179	1.70	100.00	6.67	0.55	11522	0.93

Ash results reported on an SO3-free basis.

Results reported on Dry
Basis and normalized to 100%
Screen sizes are square hole, Tyler
mesh unless designated otherwise.

Page 1 of 2

Approved:

DM Gleason

Date: JAN 31 1991

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Certificate of Analysis

Pennsylvania Electric Company
Homer City Laboratory



Description:
WYOMING-WYODAK SEAMS #90082400
RAW COAL LIBERATION
41001 AS RECEIVED RAW COAL

Lab No.: 901100014
From: CQ INC
Sampled: 09/25/90
Gross Wt.: 5205.2000 Kg

FLOAT/SINK OF PLUS 15.000 mm FRACTION REPRESENTING 16.47 % OF THE TOTAL SAMPLE

GRAVITY		DIRECT					CUMULATIVE FLOAT				
INK	FLOAT	WT %	ASH	SULFUR	BTU/LB	SO2/MBTU	WT %	ASH	SULFUR	BTU/LB	SO2/MBTU
	1.250	23.40	3.70	0.43	12311	0.69	23.40	3.70	0.43	12311	0.69
250	1.300	68.63	4.73	0.44	12152	0.72	92.03	4.47	0.44	12193	0.72
300	1.350	4.01	10.03	0.62	11503	1.43	96.04	4.70	0.45	12164	0.74
350	1.400	0.86	16.92	0.61	10619	1.14	96.90	4.81	0.45	12150	0.75
400	1.600	2.01	29.59	0.71	8861	1.60	98.90	5.31	0.46	12063	0.76
600	1.800	0.62	54.38	0.79	5595	2.81	99.52	5.62	0.46	12043	0.77
800	2.000	0.14	68.96	0.60	3640	3.24	99.67	5.71	0.46	12031	0.77
000	2.450	0.33	71.41	5.64	2780	42.04	100.00	5.93	0.48	12000	0.80
450			0.55	0.00	0	40000.00					

January 31, 1991

P.O. Box 29
Homer City, PA 15748
412-479-9011**Penelec GPU***Certificate of Analysis*Pennsylvania Electric Company
Homer City LaboratoryDescription:
WYOMING-WYODAK SEAMS #90192406
RAW COAL LIBERATION
41001 AS RECEIVED RAW COALLab No.: 901100014
From: CQ INC
Sampled: 09/25/90
Gross Wt.: 5205.2000 Kg

FLOAT/SINK OF 19.000 BY 0.600 gm FRACTION REPRESENTING 72.85 % OF THE TOTAL SAMPLE

GRAVITY		DIRECT					CUMULATIVE FLOAT				
SINK	FLOAT	WT %	ASH	SULFUR	BTU/LB	SO2/MBTU	WT %	ASH	SULFUR	BTU/LB	SO2/MBTU
	1.250	7.22	4.21	0.47	12517	0.75	7.22	4.20	0.47	12517	0.75
.250	1.300	59.54	4.47	0.43	12154	0.71	66.76	4.44	0.43	12195	0.71
.300	1.350	19.79	4.71	0.41	12110	0.68	86.55	4.51	0.43	12176	0.71
.350	1.400	3.39	7.23	0.55	11752	0.94	94.93	4.75	0.44	12137	0.73
.400	1.500	3.56	20.37	0.91	8954	1.56	98.49	5.31	0.46	12054	0.76
.600	1.800	0.72	45.82	1.26	6511	3.86	99.21	5.61	0.47	12017	0.77
.800	2.000	0.35	61.42	2.15	4226	11.15	99.56	5.81	0.47	11950	0.79
.000	2.450	0.26	59.32	5.17	2951	25.06	99.82	5.97	0.48	11967	0.81
.450		0.18	66.27	10.36	1457	104.50	100.00	6.08	0.50	11949	0.84

Page 3 of 3

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January 31, 1991

P.O. Box 29
Homer City, PA 15748
412-479-9011**Penelec GPU***Certificate of Analysis*Pennsylvania Electric Company
Homer City LaboratoryDescription:
WYOMING-WYODAK SEAMS #90192406
RAW COAL LIBERATION
41001 AS RECEIVED RAW COALLab No.: 901100014
From: CQ INC
Sampled: 09/25/90
Gross Wt.: 5205.2000 Kg

FLOAT/SINK OF 0.600 BY 0.150 gm FRACTION REPRESENTING 4.71 % OF THE TOTAL SAMPLE

GRAVITY		DIRECT					CUMULATIVE FLOAT				
SINK	FLOAT	WT %	ASH	SULFUR	BTU/LB	SO2/MBTU	WT %	ASH	SULFUR	BTU/LB	SO2/MBTU
	1.250		0.00	0.00	0	*0000.00					
.250	1.300	6.93	3.62	0.61	12547	0.97	6.93	3.62	0.61	12547	0.97
.300	1.350	29.29	3.73	0.50	12212	0.82	32.21	3.71	0.53	12284	0.86
.350	1.400	47.92	4.48	0.43	12018	0.72	80.13	4.17	0.47	12125	0.77
.400	1.500	14.90	5.38	0.58	11144	1.04	95.03	4.99	0.49	11971	0.81
.600	1.800	1.54	31.08	1.47	8165	3.61	96.58	5.41	0.50	11910	0.84
.800	2.000	0.72	45.54	3.14	6078	10.33	97.29	5.70	0.52	11868	0.86
.000	2.450	0.99	57.76	8.46	3684	45.86	98.28	6.22	0.60	11786	1.02
.450		1.72	65.17	15.25	2561	150.20	100.00	7.24	0.92	11627	1.59



Certificate of Analysis

Pennsylvania Electric Company
Homer City Laboratory



Description:
WYOMING-WYODAK SEAMS #90092400
RAW COAL LIBERATION
41001 AS RECEIVED RAW COAL

Lab No.: 901100014
From: CQ INC
Sampled: 09/25/90
Gross Wt.: 5205.2000 Kg

FLOAT/SINK OF 0.150 BY 0.075 mm FRACTION REPRESENTING 1.31 % OF THE TOTAL SAMPLE

GRAVITY SINK	FLOAT	DIRECT					CUMULATIVE FLOAT				
		WT %	ASH	SULFUR	BTU/LB	SO2/MBTU	WT %	ASH	SULFUR	BTU/LB	SO2/MBTU
	1.250		0.00	0.00	0	0.00					
250	1.300	4.71	3.69	0.59	12742	0.93	4.71	3.69	0.59	12742	0.93
300	1.350	19.53	3.76	0.56	11678	0.90	24.24	3.76	0.56	12040	0.92
350	1.400	54.62	4.44	0.45	11785	0.76	78.86	4.23	0.48	11863	0.81
400	1.500	15.65	5.61	0.54	11171	1.47	94.50	5.12	0.49	11749	0.84
600	1.600	1.59	31.55	1.15	7525	2.90	96.09	5.56	0.50	11666	0.86
800	2.000	0.58	47.92	2.20	5783	7.61	96.67	5.81	0.51	11650	0.86
1000	2.400	0.76	53.95	6.07	3555	34.15	97.44	6.27	0.56	11567	0.96
450		2.56	74.47	16.47	1852	170.86	100.00	8.01	0.96	11337	1.70

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Pennsylvania Electric Company is a Member of the General Public Utilities System

January 31, 1991

P.O. Box 29
Homer City, PA 15748
412-479-9011



Certificate of Analysis

Pennsylvania Electric Company
Homer City Laboratory



Description:
WYOMING-WYODAK SEAMS #90092400
RAW COAL LIBERATION
41001 AS RECEIVED RAW COAL

Lab No.: 901100014
From: CQ INC
Sampled: 09/25/90
Gross Wt.: 5205.2000 Kg

FLOAT/SINK OF 0.075 BY 0.000 mm FRACTION REPRESENTING 4.66 % OF THE TOTAL SAMPLE

GRAVITY SINK	FLOAT	DIRECT					CUMULATIVE FLOAT				
		WT %	ASH	SULFUR	BTU/LB	SO2/MBTU	WT %	ASH	SULFUR	BTU/LB	SO2/MBTU
	1.250		0.00	0.00	0	0.00					
250	1.300		0.00	0.00	0	0.00					
300	1.350	2.44	7.82	0.62	11980	1.03	2.44	7.82	0.62	11980	1.03
350	1.400	7.58	8.58	0.56	11684	0.96	10.02	8.40	0.57	11756	0.98
400	1.500	66.38	10.69	0.47	10585	0.86	76.40	10.39	0.48	11086	0.87
600	1.800	16.01	25.92	0.53	8483	1.24	92.41	13.08	0.49	10635	0.92
800	2.000	3.05	40.47	0.75	6380	2.35	95.46	13.95	0.50	10499	0.95
1000	2.450	2.18	70.29	1.55	2874	10.79	97.64	15.21	0.52	10329	1.01
450		2.36	84.19	1.58	919	04.32	100.00	16.84	0.55	10107	1.08

Penelec GPU

Certificate of Analysis

Pennsylvania Electric Company
Homer City Laboratory



Description:
WYOMING-WYODAK SEAMS #90092400
RAW COAL LIBERATION
41001 AS RECEIVED RAW COAL

Lab No.: 901100014
From: CQ INC
Sampled: 09/25/90
Gross wt.: 5205.2000 Kg

COMPOSITE WASHABILITY ANALYSIS OF PLUS 0.075 mm MATERIAL

GRAVITY		DIRECT					CUMULATIVE FLOAT				
SINK	FLOAT	WT %	ASH	SULFUR	BTU/LB	SO2/MBTU	WT %	ASH	SULFUR	BTU/LB	SO2/MBTU
1.250	1.250	9.11	3.99	0.45	12430	0.73	9.11	3.99	0.45	12430	0.73
1.250	1.350	55.07	4.71	0.43	12150	0.71	64.18	4.44	0.44	12197	0.72
1.300	1.350	16.64	4.15	0.44	12091	0.72	80.82	4.53	0.44	12175	0.72
1.350	1.400	9.55	6.17	0.52	11780	0.80	90.37	4.75	0.45	12133	0.73
1.400	1.600	5.92	15.09	0.68	10510	1.31	97.31	5.40	0.46	12019	0.77
1.600	1.600	1.47	35.45	0.76	7571	2.22	98.78	5.93	0.47	11952	0.78
1.600	2.000	0.46	53.95	1.71	5020	6.40	99.24	6.15	0.47	11920	0.80
2.000	2.450	0.40	68.39	4.75	3320	21.50	99.64	6.40	0.49	11884	0.83
2.450		0.35	70.32	10.25	1750	125.50	100.00	6.67	0.53	11848	0.89

Page 7 of 8

Pennsylvania Electric Company is a Member of the General Public Utilities System

January 31, 1991

P.O. Box 29
Homer City, PA 15748
412-479-9011

Penelec GPU

Certificate of Analysis

Pennsylvania Electric Company
Homer City Laboratory



Description:
WYOMING-WYODAK SEAMS #90092400
RAW COAL LIBERATION
41001 AS RECEIVED RAW COAL

Lab No.: 901100014
From: CQ INC
Sampled: 09/25/90
Gross wt.: 5205.2000 Kg

COMPOSITE SIZE DISTRIBUTION ANALYSIS

SIZE IN mm		DIRECT					CUMULATIVE RETAINED				
SSD	RETAIN	WT %	ASH	SULFUR	BTU/LB	SO2/MBTU	WT %	ASH	SULFUR	BTU/LB	SO2/MBTU
	19.000	16.47	5.93	0.48	12000	0.80	16.47	5.93	0.48	12000	0.80
9.000	0.600	72.85	6.08	0.50	11940	0.84	89.32	6.05	0.50	11958	0.83
0.600	0.150	4.71	7.24	0.92	11427	1.05	94.03	6.11	0.52	11942	0.87
0.150	0.075	1.31	8.01	0.96	11337	1.70	95.34	6.14	0.52	11933	0.88
0.075		4.66	16.84	0.55	10107	1.00	100.00	6.63	0.53	11848	0.89

APPENDIX C

Croweburg Seam Raw Coal Liberation Data

Penelec GPU**Certificate of Analysis**Pennsylvania Electric Company
Homer City LaboratoryDescription:
CROWEBURG RAW COAL/LIBERATION
RUN #90051900
41001 CRUSHED TO 3/4" X 0Lab No.: 900700472
From: CO INC
Sampled: / /
Gross Wt.: 713.6000 Kg

SIZE IN mm		DIRECT					CUMULATIVE RETAINED				
ASSED	RETAIN	WT %	ASH	SULFUR	BTU/LB	SO2/MBTU	WT %	ASH	SULFUR	BTU/LB	SO2/MBTU
19.000	19.000	1.70	10.62	0.70	13213	1.06	1.70	10.62	0.70	13213	1.06
9.500	9.500	27.84	8.03	0.61	13632	0.90	29.54	8.18	0.62	13608	0.91
0.600	0.600	55.20	8.97	0.68	13392	1.02	84.74	8.69	0.66	13467	0.98
0.150	0.150	5.51	17.99	0.75	11373	1.33	90.25	9.26	0.66	13339	1.00
0.075	0.075	2.15	28.82	0.78	9893	1.57	92.40	9.72	0.67	13259	1.01
0.000	0.000	7.60	54.25	0.60	6021	2.50	100.00	13.10	0.66	12709	1.04

Results reported on Dry
basis and normalized to 100%
Screen sizes are square hole, Tyler
mesh unless designated otherwise.Page 1 of 7 Approved: *Don Shesney*Date: SEP 28 1990

Pennsylvania Electric Company is a Member of the General Public Utilities System

October 22, 1990

P.O. Box 29
Homer City, PA 15748
412-479-9011**Penelec GPU****Certificate of Analysis**Pennsylvania Electric Company
Homer City LaboratoryDescription:
CROWEBURG RAW COAL/LIBERATION
RUN #90051900
41001 CRUSHED TO 3/4" X 0Lab No.: 900700472
From: CO INC
Sampled: / /
Gross Wt.: 713.6000 Kg

FLOAT/SINK OF PLUS BY 0.600 mm FRACTION REPRESENTING 84.74 % OF THE TOTAL SAMPLE

GRAVITY		DIRECT					CUMULATIVE FLOAT				
SINK	FLOAT	WT %	ASH	SULFUR	BTU/LB	SO2/MBTU	WT %	ASH	SULFUR	BTU/LB	SO2/MBTU
	1.250	31.48	1.80	0.48	14657	0.65	31.48	1.80	0.48	14657	0.65
.250	1.300	48.75	4.15	0.56	14240	0.79	80.22	3.23	0.53	14403	0.73
.300	1.350	5.62	9.62	0.79	13385	1.18	85.85	3.65	0.54	14337	0.76
.350	1.400	3.28	13.90	0.78	12537	1.24	89.13	4.03	0.55	14270	0.78
.400	1.600	4.12	23.55	0.82	10986	1.50	93.25	4.89	0.57	14125	0.80
.600	1.800	0.96	34.68	1.11	8384	2.64	94.21	5.19	0.57	14067	0.81
.800	2.000	0.58	42.70	2.96	6460	5.18	94.80	5.42	0.59	14020	0.84
.000	2.450	1.60	73.83	1.28	2145	11.94	96.40	6.56	0.60	13822	0.86
.450		3.60	79.00	1.34	282	54.70	100.00	9.17	0.62	13335	0.94



Certificate of Analysis

Pennsylvania Electric Company
Homer City Laboratory



Description:
CROWEBURG RAW COAL/LIBERATION
RUN #90051900
41001 CRUSHED TO 3/4" X 0

Lab No.: 900700472
From: CQ INC
Sampled: / /
Gross Wt.: 713.6000 Kg

FLOAT/SINK OF 0.600 BY 0.150 mm FRACTION REPRESENTING 5.51 % OF THE TOTAL SAMPLE

GRAVITY		-----DIRECT-----					-----CUMULATIVE FLOAT-----				
SINK	FLOAT	WT %	ASH	SULFUR	BTU/LB	SO2/MBTU	WT %	ASH	SULFUR	BTU/LB	SO2/MBTU
	1.250	40.36	1.12	0.55	14552	0.75	40.36	1.12	0.55	14552	0.75
.250	1.300	19.62	2.63	0.62	14401	0.86	59.98	1.62	0.57	14502	0.79
.300	1.350	8.96	4.95	0.66	14036	0.94	68.94	2.05	0.58	14442	0.81
.350	1.400	4.25	9.45	0.75	13353	1.12	73.20	2.48	0.59	14378	0.82
.400	1.600	4.37	19.84	0.90	11663	1.54	77.57	3.46	0.61	14225	0.86
.600	1.800	1.46	35.84	1.06	8944	2.38	79.03	4.06	0.62	14128	0.87
.800	2.000	1.06	45.64	1.21	6667	3.62	80.09	4.61	0.63	14029	0.89
.000	2.450	2.41	64.58	1.14	2735	8.34	82.50	6.36	0.64	13699	0.93
.450		17.50	72.42	1.03	26	774.56	100.00	17.92	0.71	11307	1.25



Certificate of Analysis

Pennsylvania Electric Company
Homer City Laboratory

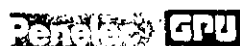


Description:
CROWEBURG RAW COAL/LIBERATION
RUN #90051900
41001 CRUSHED TO 3/4" X 0

Lab No.: 900700472
From: CQ INC
Sampled: / /
Gross Wt.: 713.6000 Kg

FLOAT/SINK OF 0.150 BY 0.075 mm FRACTION REPRESENTING 2.15 % OF THE TOTAL SAMPLE

GRAVITY		-----DIRECT-----					-----CUMULATIVE FLOAT-----				
SINK	FLOAT	WT %	ASH	SULFUR	BTU/LB	SO2/MBTU	WT %	ASH	SULFUR	BTU/LB	SO2/MBTU
	1.250	23.27	0.84	0.52	14566	0.71	23.27	0.84	0.52	14566	0.71
.250	1.300	25.86	2.47	0.51	14321	0.72	49.13	1.70	0.52	14437	0.71
.300	1.350	7.50	4.18	0.59	14093	0.83	56.63	2.02	0.52	14392	0.73
.350	1.400	4.80	7.49	0.62	13540	0.91	61.43	2.45	0.53	14325	0.74
.400	1.600	4.18	13.75	0.67	12702	1.06	65.61	3.17	0.54	14222	0.76
.600	1.800	2.41	25.89	0.75	10632	1.42	68.02	3.98	0.55	14095	0.78
.800	2.000	1.52	46.33	1.02	6811	3.00	69.54	4.90	0.56	13935	0.80
.000	2.450	1.98	66.06	1.08	3177	6.79	71.52	6.60	0.57	13637	0.84
.450		28.48	82.78	1.06	65	314.24	100.00	28.29	0.71	9772	1.46



Certificate of Analysis

Pennsylvania Electric Company
Homer City Laboratory



Description:
CROWEBURG RAW COAL/LIBERATION
RUN #90051900
41001 CRUSHED TO 3/4" X 0

Lab No.: 900700472
From: CQ INC
Sampled: / /
Gross Wt.: 713.6000 Kg

FLOAT/SINK OF 0.075 BY 0.000 mm FRACTION REPRESENTING 7.60 % OF THE TOTAL SAMPLE

GRAVITY		DIRECT					CUMULATIVE FLOAT				
SINK	FLOAT	WT %	ASH	SULFUR	BTU/LB	SO2/MBTU	WT %	ASH	SULFUR	BTU/LB	SO2/MBTU
	1.250		0.00	0.00	0	0.00					
.250	1.300		0.00	0.00	0	0.00					
.300	1.350	1.96	6.55	0.52	13709	0.76	1.96	6.55	0.52	13709	0.76
.350	1.400		0.00	0.00	0	0.00					
.400	1.600	3.99	15.75	0.48	12244	0.78	5.94	12.73	0.49	12726	0.77
.600	1.800	13.35	28.17	0.39	10266	0.76	19.30	23.41	0.42	11024	0.76
.800	2.000	36.03	39.10	0.33	8371	0.74	55.33	33.69	0.36	9296	0.76
.000	2.450	25.72	68.47	0.39	3914	2.01	81.05	44.72	0.37	7588	0.98
.450		18.95	87.65	1.61	512	62.63	100.00	52.86	0.61	6247	1.94

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October 22, 1990

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Pennsylvania Electric Company
Homer City Laboratory



Description:
CROWEBURG RAW COAL/LIBERATION
RUN #90051900
41001 CRUSHED TO 3/4" X 0

Lab No.: 900700472
From: CQ INC
Sampled: / /
Gross Wt.: 713.6000 Kg

COMPOSITE WASHABILITY ANALYSIS OF PLUS BY 0.000 mm MATERIAL

GRAVITY		DIRECT					CUMULATIVE FLOAT				
SINK	FLOAT	WT %	ASH	SULFUR	BTU/LB	SO2/MBTU	WT %	ASH	SULFUR	BTU/LB	SO2/MBTU
	1.250	29.40	1.74	0.48	14647	0.66	29.40	1.74	0.48	14647	0.66
1.250	1.300	42.94	4.09	0.56	14245	0.79	72.34	3.13	0.53	14408	0.73
1.300	1.350	5.57	8.97	0.76	13472	1.14	77.91	3.55	0.55	14341	0.76
1.350	1.400	3.12	13.35	0.77	12632	1.22	81.03	3.93	0.55	14276	0.78
1.400	1.600	4.12	22.55	0.80	11155	1.43	85.15	4.83	0.57	14124	0.80
1.600	1.800	1.96	31.13	0.72	9439	1.54	87.12	5.42	0.57	14019	0.81
1.800	2.000	3.33	39.90	0.74	8041	1.85	90.44	6.69	0.58	13799	0.84
2.000	2.450	3.49	70.38	0.76	3171	4.90	93.53	9.06	0.58	13404	0.87
2.450		6.07	80.39	1.33	274	96.49	100.00	13.39	0.63	12608	1.00

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Description:
CROWEBURG RAW COAL/LIBERATION
RUN #50051900
41001 CRUSHED TO 3/4" X 0

Lab No.: 900700472
From: CQ INC
Sampled: / /
Gross Wt.: 713.6000 Kg

COMPOSITE SIZE DISTRIBUTION ANALYSIS

SIZE IN mm		-----DIRECT-----					-----CUMULATIVE RETAINED-----				
ASSSED	RETAIN	WT %	ASH	SULFUR	BTU/LB	SO2/MBTU	WT %	ASH	SULFUR	BTU/LB	SO2/MBTU
	0.600	84.74	9.17	0.62	13335	0.94	84.74	9.17	0.62	13335	0.94
0.600	0.150	5.51	17.92	0.71	11307	1.25	90.25	9.70	0.63	13211	0.95
0.150	0.075	2.15	28.29	0.71	9772	1.46	92.40	10.14	0.63	13131	0.96
0.075		7.60	52.86	0.61	8247	1.94	100.00	13.39	0.63	12608	1.00

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Pennsylvania Electric Company
Homer City Laboratory

Certificate of Analysis

Description:
CROWEBURG RAW COAL/LIBERATION
RUN #90051900
41001 CRUSHED TO 3/4" X 0
TOTAL SAMPLE

Lab No.: 900700472
From: CQ INC
Sampled: / /
Gross Wt.: 713.6000 Kg

PARAMETER AS RECEIVED MOISTURE FREE

% Ash	11.79	13.06
% Total Moisture	9.66	



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Pennsylvania Electric Company
Homer City Laboratory

description:
CROWDERG RAW COAL/LIBERATION
RUN #90051900
41001 CRUSHED TO 3/8" X 0

Lab No.: 900700473
From: CG INC
Sampled: / /
Gross Wt.: 132.8000 Kg

SIZE IN mm.		---DIRECT---					---CUMULATIVE RETAINED---				
ASSSED	RETAIN	WT %	ASH	SULFUR	BTU/LB	SO ₂ /MBTU	WT %	ASH	SULFUR	BTU/LB	SO ₂ /MBTU
	9.500	1.98	10.69	0.63	13196	0.95	1.98	10.69	0.63	13196	0.95
9.500	0.600	81.98	8.96	0.67	13410	1.01	83.96	9.00	0.67	13405	1.00
0.600	0.150	5.64	15.32	0.71	11761	1.21	89.60	9.40	0.68	13301	1.02
0.150	0.075	2.39	25.89	0.76	10194	1.49	91.88	9.83	0.68	13221	1.03
0.075		8.02	54.92	0.59	6112	1.50	100.00	13.44	0.67	12651	1.06

Results reported on Dry
Basis and normalized to 100%
Screen sizes are square hole, Tyler
mesh unless designated otherwise.

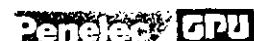
Page 1 of 7 Approved:

Don Blasing Date: SEP 20 1990

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October 22, 1990

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Certificate of Analysis

Pennsylvania Electric Company
Homer City Laboratory

description:
CROWEBURG RAW COAL/LIBERATION
RUN #90051900
41001 CRUSHED TO 3/8" X 0

Lab No.: 900700473
From: CG INC
Sampled: / /
Gross Wt.: 132.8000 Kg

FLOAT/SINK OF PLUS BY 0.600 mm FRACTION, REPRESENTING 83.96 % OF THE TOTAL SAMPLE

GRAVITY		DIRECT					CUMULATIVE FLOAT				
SINK	FLOAT	WT %	ASH	SULFUR	BTU/LB	SO ₂ /MBTU	WT %	ASH	SULFUR	BTU/LB	SO ₂ /MBTU
	1.250	31.10	1.84	0.46	14734	0.63	31.10	1.84	0.46	14734	0.63
.250	1.300	44.64	3.60	0.55	14471	0.77	75.73	2.88	0.52	14579	0.71
.300	1.350	10.10	8.96	0.73	13519	1.08	85.83	3.59	0.54	14454	0.75
.350	1.400	3.20	14.22	0.86	12609	1.36	89.03	3.97	0.55	14388	0.77
.400	1.600	4.24	23.94	0.85	10990	1.54	93.27	4.88	0.57	14234	0.80
.600	1.800	1.07	35.35	1.27	8296	3.05	94.34	5.23	0.57	14166	0.81
.800	2.000	0.64	40.51	1.51	6383	4.74	94.97	5.46	0.58	14114	0.82
.000	2.450	1.58	71.07	1.59	2326	13.63	96.55	6.53	0.60	13922	0.86
.450		3.45	77.62	1.86	361	103.03	100.00	8.99	0.64	13454	0.99

Pennsylvania Electric Company
Homer City Laboratory



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Description:
CROWEBURG RAW COAL/LIBERATION
RUN #90051900
41001 CRUSHED TO 3/8" X 0

Lab No.: 900700473
From: CG INC
Sampled: / /
Gross Wt.: 132.8000 Kg

FLOAT/SINK OF 0.600 BY 0.150 mm FRACTION REPRESENTING 5.64 % OF THE TOTAL SAMPLE

GRAVITY		DIRECT					CUMULATIVE FLOAT				
SINK	FLOAT	WT %	ASH	SULFUR	BTU/LB	SO2/MBTU	WT %	ASH	SULFUR	BTU/LB	SO2/MBTU
	1.250	47.76	1.03	0.55	14658	0.74	47.76	1.03	0.55	14658	0.74
.250	1.300	16.52	2.94	0.63	14321	0.88	64.28	1.53	0.57	14572	0.78
.300	1.350	8.54	5.35	0.65	13956	0.93	72.81	1.98	0.58	14500	0.80
.350	1.400	3.62	10.18	0.77	13112	1.18	76.43	2.37	0.59	14434	0.81
.400	1.600	3.87	20.70	0.98	11527	1.70	80.29	3.25	0.61	14294	0.85
.600	1.800	1.30	35.00	1.18	8960	2.64	81.60	3.76	0.61	14209	0.87
.800	2.000	0.85	43.76	1.39	6911	4.02	82.45	4.17	0.62	14133	0.88
.000	2.450	2.15	61.60	1.22	2860	8.54	84.60	5.63	0.64	13846	0.92
.450		15.40	67.10	1.23	76	321.27	100.00	15.00	0.73	11726	1.24

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October 22, 1990

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Pennsylvania Electric Company
Homer City Laboratory



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Description:
CROWEBURG RAW COAL/LIBERATION
RUN #90051900
41001 CRUSHED TO 3/8" X 0

Lab No.: 900700473
From: CG INC
Sampled: / /
Gross Wt.: 132.8000 Kg

FLOAT/SINK OF 0.150 BY 0.075 mm FRACTION REPRESENTING 2.39 % OF THE TOTAL SAMPLE

GRAVITY		DIRECT					CUMULATIVE FLOAT				
SINK	FLOAT	WT %	ASH	SULFUR	BTU/LB	SO2/MBTU	WT %	ASH	SULFUR	BTU/LB	SO2/MBTU
	1.250	21.15	0.93	0.49	14726	0.67	21.15	0.93	0.49	14726	0.67
.250	1.300	27.06	2.01	0.51	14464	0.71	48.21	1.54	0.50	14579	0.69
.300	1.350	9.74	3.10	0.51	14202	0.72	57.94	1.80	0.51	14515	0.70
.350	1.400	7.45	7.16	0.59	13586	0.87	65.39	2.41	0.52	14410	0.72
.400	1.600	3.97	15.68	0.73	12308	1.19	69.36	3.17	0.53	14289	0.74
.600	1.800	2.37	30.46	0.93	9890	1.88	71.73	4.07	0.54	14144	0.77
.800	2.000	1.33	45.83	1.22	7031	3.48	72.75	4.66	0.55	14044	0.78
.000	2.450	1.91	66.37	1.16	3024	7.64	74.67	6.24	0.57	13762	0.82
.450		25.33	81.69	1.34	23	1115.78	100.00	25.36	0.76	10281	1.46

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Pennsylvania Electric Company
Homer City Laboratory



description:
CROWEBURG RAW COAL/LIBERATION
RUN #90051900
41001 CRUSHED TO 3/8" X 0

Lab No.: 900700473
From: CQ INC
Sampled: / /
Gross Wt.: 132.8000 Kg

FLOAT/SINK OF 0.075 BY 0.000 mm FRACTION REPRESENTING 6.02 % OF THE TOTAL SAMPLE

GRAVITY INK	FLOAT	-----DIRECT-----					-----CUMULATIVE FLOAT-----				
		WT %	ASH	SULFUR	BTU/LB	SO2/MBTU	WT %	ASH	SULFUR	BTU/LB	SO2/MBTU
	1.250		0.00	0.00	0	0.00					
250	1.300		0.00	0.00	0	0.00					
300	1.350	5.58	8.69	0.46	13354	0.69	5.58	8.69	0.46	13354	0.69
350	1.400	1.22	10.46	0.57	12965	0.88	6.80	9.01	0.48	13285	0.72
400	1.450	9.30	16.84	0.41	12100	0.67	16.11	13.54	0.44	12600	0.65
600	1.600	12.31	24.86	0.31	10873	0.57	28.42	18.44	0.38	11852	0.54
800	2.000	23.54	46.45	0.35	7225	0.97	51.96	31.13	0.37	9756	0.75
000	2.450	23.26	68.93	0.38	3784	2.03	75.22	42.82	0.37	7909	0.94
450		24.78	66.73	1.12	764	29.26	100.00	53.70	0.56	6138	1.82

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Pennsylvania Electric Company
Homer City Laboratory



description:
CROWEBURG RAW COAL/LIBERATION
RUN #90051900
41001 CRUSHED TO 3/8" X 0

Lab No.: 900700473
From: CQ INC
Sampled: / /
Gross Wt.: 132.8000 Kg

COMPOSITE WASHABILITY ANALYSIS OF PLUS BY 0.000 mm MATERIAL

GRAVITY SINK	FLOAT	-----DIRECT-----					-----CUMULATIVE FLOAT-----				
		WT %	ASH	SULFUR	BTU/LB	SO2/MBTU	WT %	ASH	SULFUR	BTU/LB	SO2/MBTU
	1.250	29.31	1.75	0.47	14727	0.64	29.31	1.75	0.47	14727	0.64
1.250	1.300	39.05	3.56	0.56	14468	0.77	68.36	2.78	0.52	14579	0.71
1.300	1.350	9.64	8.63	0.71	13550	1.04	78.00	3.50	0.54	14452	0.75
1.350	1.400	3.17	13.44	0.83	12707	1.30	81.17	3.89	0.55	14383	0.77
1.400	1.450	4.62	22.47	0.78	11221	1.39	85.78	4.89	0.57	14213	0.80
1.600	1.800	2.01	30.06	0.78	9629	1.63	87.80	5.47	0.57	14108	0.81
1.800	2.000	2.49	45.12	0.63	7037	1.79	90.29	6.56	0.57	13913	0.82
2.000	2.450	3.36	69.47	0.90	3165	5.66	93.65	8.82	0.58	13528	0.86
2.450		6.35	79.42	1.49	416	71.72	100.00	13.31	0.64	12694	1.01

Pennsylvania Electric Company
Homer City Laboratory



Certificate of Analysis

Description:
CROWESBURG RAW COAL/LIBERATION
RUN #90051900
41001 CRUSHED TO 3/8" X 0

Lab No.: 900700473
From: CQ INC
Sampled: / /
Gross Wt.: 132.8000 Kg

COMPOSITE SIZE DISTRIBUTION ANALYSIS

SIZE IN mm		DIRECT					CUMULATIVE RETAINED				
ASSSED	RETAIN	WT %	ASH	SULFUR	BTU/LB	SO2/MBTU	WT %	ASH	SULFUR	BTU/LB	SO2/MBTU
	0.600	83.96	8.59	0.64	13454	0.95	83.96	8.99	0.64	13454	0.95
0.600	0.150	5.64	15.09	0.73	11726	1.24	89.60	9.37	0.65	13345	0.97
0.150	0.075	2.39	25.36	0.76	10281	1.46	91.98	9.78	0.65	13266	0.98
0.075		8.02	53.70	0.56	6139	1.82	100.00	13.31	0.64	12694	1.01

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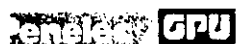
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Penelec GPU

Description:
CROWESBURG RAW COAL/LIBERATION
RUN #90051900
41001 CRUSHED TO 3/8" X 0
TOTAL SAMPLE

Lab No.: 900700473
From: CQ INC
Sampled: / /
Gross Wt.: 132.8000 Kg

PARAMETER	AS RECEIVED	MOISTURE FREE	Major Elements in Ash	
PROXIMATE			% SiO2	47.04
% Total Moisture	9.42		% Al2O3	15.69
% Ash	11.92	13.16	% Fe2O3	11.24
% Volatile (non-sparking)	30.58	33.76	% CaO	16.51
% Fixed Carbon (by difference)	48.07	53.08	% MgO	1.32
TIMATE			% Na2O	0.64
% Carbon	64.33	71.02	% K2O	2.47
% Hydrogen	3.99	4.41	% TiO2	0.70
% Nitrogen	1.36	1.50	% MnO2	0.22
% Total Sulfur	0.63	0.69	% P2O5	0.37
% Ash	11.92	13.16	% SO3	2.19
% Oxygen (by difference)	8.35	9.22		
Sulfur Forms			TOTAL %	98.40
% Pyritic Sulfur	0.25	0.28		
% Sulfate Sulfur	0.01	0.01		
% Organic Sulfur	0.37	0.40		
Calorific Value (BTU/Lb)	11478	12672	Grindability	62
% Chlorine	0.22	0.24		



Certificate of Analysis

Pennsylvania Electric Company
Homer City Laboratory



scription:
CROWBURG RAW COAL/LIBERATION
RUN #90051900
41001 CRUSHED TO 3/8" X 0
TOTAL SAMPLE

Lab No.: 900700473
From: CQ INC
Sampled: / /
Gross Wt.: 132.8000 Kg

ASH FUSIBILITY

	REDUCING ATMOSPHERE Degrees Farenheit	OXIDIZING ATMOSPHERE Degrees Farenheit
Initial Deformation Temperature	2064	2147
Softening Temperature	2111	2207
Hemispherical Temperature	2149	2267
Fluid Temperature	2215	2357

2750+ Signifies Fusion Temperature
exceeds instrument capabilities

Approved: _____

Don Glessner

Date: SEP 28 1990

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WASHABILITY ANALYSIS

Pennsylvania Electric Company
Homer City Laboratory



Description:
CROWEBURG RAW COAL/LIBERATION
RUN #90051900
41001 CRUSHED TO 28M X 0

Lab No.: 900700474
From: CQ INC
Sampled: / /
Gross Wt.: 66.9000 Kg

SIZE IN mm		DIRECT					CUMULATIVE RETAINED				
ASSED	RETAIN	WT %	ASH	SULFUR	BTU/LB	SO2/MBTU	WT %	ASH	SULFUR	BTU/LB	SO2/MBTU
0.600	0.600	2.43	10.21	0.87	13164	1.33	2.43	10.21	0.87	13164	1.33
0.600	0.150	51.88	8.11	0.66	13476	0.98	54.31	8.20	0.67	13462	0.99
0.150	0.075	21.53	10.23	0.67	13150	1.32	75.84	8.78	0.67	13374	1.00
0.075		24.16	28.39	0.63	13281	1.03	100.00	13.52	0.66	12626	1.04

Results reported on Dry
Basis and normalized to 100%
Screen sizes are square hole, Tyler
mesh unless designated otherwise.

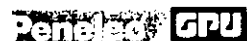
Page 1 of 1 Approved: *Dm. L. L...*

Date: OCT 22 1990

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October 22, 1990

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Homer City, PA 15748
412-479-9011



Certificate of Analysis

Pennsylvania Electric Company
Homer City Laboratory



Description:
CROWEBURG RAW COAL/LIBERATION
RUN #90051900
41001 CRUSHED TO 28M X 0

Lab No.: 900700474
From: CQ INC
Sampled: / /
Gross Wt.: 66.9000 Kg

FLOAT/SINK OF PLUS BY 0.150 mm FRACTION REPRESENTING 54.31 % OF THE TOTAL SAMPLE

GRAVITY		DIRECT					CUMULATIVE FLOAT				
SINK	FLOAT	WT %	ASH	SULFUR	BTU/LB	SO2/MBTU	WT %	ASH	SULFUR	BTU/LB	SO2/MBTU
	1.250	56.57	1.59	0.48	14508	0.66	56.57	1.59	0.48	14508	0.66
.250	1.300	19.14	3.98	0.57	14089	0.81	75.71	2.19	0.50	14402	0.69
.300	1.350	6.96	6.40	0.61	13810	0.88	82.67	2.55	0.51	14352	0.71
.350	1.400	5.31	10.29	0.66	13237	1.00	87.98	3.01	0.52	14285	0.73
.400	1.600	4.31	21.72	0.90	11443	1.57	92.29	3.89	0.54	14152	0.76
.600	1.800	1.38	37.89	1.07	8707	2.46	93.67	4.39	0.54	14072	0.77
.800	2.000	0.61	47.22	1.47	6266	4.69	94.29	4.67	0.55	14021	0.79
.000	2.450	0.92	59.45	1.76	3342	10.55	95.20	5.20	0.56	13918	0.81
.450		4.80	69.42	2.60	266	195.02	100.00	8.28	0.66	13263	0.99



Certificate of Analysis

Pennsylvania Electric Company
Homer City Laboratory



Description:
CROWEBURG RAW COAL/LIBERATION
RUN #90051900
#1001 CRUSHED TO 28M X 0

Lab No.: 900700474
From: CG INC
Sampled: / /
Gross Wt.: 66.9000 Kg

FLOAT/SINK OF 0.150 BY 0.075 mm FRACTION REPRESENTING 21.53 % OF THE TOTAL SAMPLE

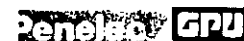
GRAVITY		DIRECT					CUMULATIVE FLOAT				
SINK	FLOAT	WT %	ASH	SULFUR	BTU/LB	SO2/MBTU	WT %	ASH	SULFUR	BTU/LB	SO2/MBTU
	1.250	49.49	1.04	0.46	14465	0.63	49.49	1.04	0.46	14465	0.63
.250	1.300	21.25	2.63	0.53	14256	0.74	70.74	1.52	0.48	14402	0.66
.300	1.350	10.68	4.87	0.54	13901	0.78	81.42	1.96	0.49	14336	0.68
.350	1.400	4.61	9.93	0.62	13078	0.95	86.03	2.39	0.49	14269	0.69
.400	1.600	3.46	19.09	0.80	11744	1.37	89.49	3.03	0.51	14171	0.71
.600	1.800	1.38	54.24	0.99	9254	2.14	90.87	3.51	0.51	14096	0.73
.800	2.000		0.00	0.00		0.00					
.000	2.450	1.27	55.03	1.52	4995	6.09	92.14	4.22	0.53	13971	0.75
.450		7.86	77.22	2.02	226	178.72	100.00	9.95	0.64	12891	1.00

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October 23, 1990

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Homer City, PA 15748
412-479-9011



Certificate of Analysis

Pennsylvania Electric Company
Homer City Laboratory



Description:
CROWEBURG RAW COAL/LIBERATION
RUN #90051900
#1001 CRUSHED TO 28M X 0

Lab No.: 900700474
From: CG INC
Sampled: / /
Gross Wt.: 66.9000 Kg

FLOAT/SINK OF 0.075 BY 0.000 mm FRACTION REPRESENTING 24.16 % OF THE TOTAL SAMPLE

GRAVITY		DIRECT					CUMULATIVE FLOAT				
SINK	FLOAT	WT %	ASH	SULFUR	BTU/LB	SO2/MBTU	WT %	ASH	SULFUR	BTU/LB	SO2/MBTU
	1.250	7.78	1.15	0.44	14750	0.60	7.78	1.15	0.44	14750	0.60
.250	1.300	13.28	2.69	0.46	14384	0.64	21.06	2.12	0.45	14519	0.62
.300	1.350	19.18	3.87	0.46	14211	0.64	40.24	2.96	0.45	14372	0.63
.350	1.400	10.07	6.56	0.47	13775	0.68	50.32	3.68	0.46	14253	0.64
.400	1.600	7.65	12.07	0.47	12959	0.73	57.97	4.79	0.46	14082	0.65
.600	1.800	7.95	27.12	0.44	10528	0.84	65.92	7.48	0.46	13653	0.67
.800	2.000	6.25	48.27	0.42	6903	1.23	72.17	11.01	0.45	13069	0.70
.000	2.450	15.81	66.13	0.38	4274	1.77	87.97	20.91	0.44	11489	0.77
.450		12.03	78.25	1.78	1822	19.53	100.00	27.81	0.60	10326	1.17



Certificate of Analysis

Pennsylvania Electric Company
Homer City Laboratory



Description:
CROWEBURG RAW COAL/LIBERATION
RUN #90051903
41001 CRUSHED TO 28M X 0

Lab No.: 900700474
From: CG INC
Sampled: / /
Gross Wt.: 66.9000 Kg

COMPOSITE WASHABILITY ANALYSIS OF FLUS BY 0.000 mm MATERIAL

GRAVITY		DIRECT					CUMULATIVE FLOAT				
SINK	FLOAT	WT %	ASH	SULFUR	BTU/LB	SO2/MBTU	WT %	ASH	SULFUR	BTU/LB	SO2/MBTU
1.250	1.250	43.26	1.43	0.47	14508	0.65	43.26	1.43	0.47	14508	0.65
1.250	1.300	19.18	3.41	0.54	14183	0.76	61.43	2.02	0.49	14412	0.68
1.300	1.350	10.72	4.98	0.53	14003	0.70	72.15	2.46	0.50	14351	0.69
1.350	1.400	6.31	8.80	0.58	13420	0.87	78.46	2.97	0.50	14276	0.71
1.400	1.400	4.93	17.71	0.72	12057	1.21	83.39	3.84	0.52	14145	0.73
1.600	1.600	2.97	30.85	0.66	9940	1.37	86.36	4.76	0.52	14000	0.74
1.800	2.000	1.64	48.18	0.61	6758	1.81	88.01	5.66	0.52	13849	0.76
2.000	2.450	4.54	64.74	0.60	4216	2.83	92.80	8.59	0.53	13373	0.79
2.450		7.20	74.82	2.13	885	46.20	100.00	13.36	0.64	12473	1.03

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October 22, 1990

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Certificate of Analysis

Pennsylvania Electric Company
Homer City Laboratory



Description:
CROWEBURG RAW COAL/LIBERATION
RUN #90051903
41001 CRUSHED TO 28M X 0

Lab No.: 900700474
From: CG INC
Sampled: / /
Gross Wt.: 66.9000 Kg

COMPOSITE SIZE DISTRIBUTION ANALYSIS

SIZE IN mm		DIRECT					CUMULATIVE RETAINED				
ASSESSED	RETAIN	WT %	ASH	SULFUR	BTU/LB	SO2/MBTU	WT %	ASH	SULFUR	BTU/LB	SO2/MBTU
	0.150	54.31	8.28	0.66	13263	0.99	54.31	8.28	0.66	13263	0.99
0.150	0.075	21.53	9.95	0.64	12891	1.00	75.84	8.75	0.66	13157	1.00
0.075		24.16	27.81	0.60	10326	1.17	100.00	13.36	0.64	12473	1.03

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Homer City, PA 15748
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Pennsylvania Electric Company
Homer City Laboratory



Certificate of Analysis

Lab No.: 900700474
From: CQ INC
Sampled: / /
Gross Wt.: 66.9000 Kg

Description:
CROWBURG RAW COAL/LIBERATION
RUN #9C051903
41001 CRUSHED TO 26M X 0
TOTAL SAMPLE

PARAMETER	AS RECEIVED	MOISTURE FREE
% Ash	12.33	13.44
% Total Moisture	8.29	

Approved: _____

Don Glasney

Date: OCT 22 1990

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Certificate of Analysis

WASHABILITY ANALYSIS

Pennsylvania Electric Company
Homer City Laboratory



Description:
CROWBURG RAW COAL/LIBERATION
RUN #90051900
41001 CRUSHED TO 100M X 0

Lab No.: 900700475
From: CQ INC
Sampled: / /
Gross Wt.: 20.1705 Kg

SIZE IN mm		DIRECT					CUMULATIVE RETAINED				
SSD	RETAIN	WT %	ASH	SULFUR	BTU/LB	SO2/MBTU	WT %	ASH	SULFUR	BTU/LB	SO2/MBTU
0.150	0.150	2.91	10.00	0.59	13276	0.89	2.91	10.00	0.59	13276	0.89
0.150	0.075	36.60	9.40	0.58	13206	0.87	39.50	9.44	0.58	13211	0.88
0.075		60.50	16.48	0.77	12156	1.00	100.00	13.70	0.69	12572	1.10

Results reported on Dry
Basis and normalized to 100%
Screen sizes are square hole, Tyler
mesh unless designated otherwise.

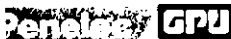
Page 1 of 5 Approved: DM Gleason

Date: OCT 22 1990

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October 22, 1990

P.O. Box 29
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412-479-9011



Certificate of Analysis

Pennsylvania Electric Company
Homer City Laboratory



Description:
CROWBURG RAW COAL/LIBERATION
RUN #90051900
41001 CRUSHED TO 100M X 0

Lab No.: 900700475
From: CQ INC
Sampled: / /
Gross Wt.: 20.1705 Kg

FLOAT/SINK OF PLUS BY 0.075 mm FRACTION REPRESENTING 39.50 % OF THE TOTAL SAMPLE

GRAVITY		DIRECT					CUMULATIVE FLOAT				
SINK	FLOAT	WT %	ASH	SULFUR	BTU/LB	SO2/MBTU	WT %	ASH	SULFUR	BTU/LB	SO2/MBTU
	1.250	42.12	1.20	0.46	14742	0.62	42.12	1.20	0.46	14742	0.62
.250	1.300	24.80	2.63	0.48	14445	0.67	66.92	1.73	0.47	14632	0.64
.300	1.350	14.67	4.90	0.51	14085	0.72	81.59	2.30	0.48	14534	0.65
.350	1.400	5.31	10.95	0.56	13158	0.86	86.90	2.83	0.48	14450	0.67
.400	1.600	3.91	20.81	0.69	11619	1.19	90.81	3.60	0.49	14328	0.68
.600	1.800	1.67	35.42	0.68	9253	1.47	92.49	4.18	0.49	14236	0.69
.800	2.000		0.00	0.00	0	0.00					
.000	2.450	1.27	58.55	0.92	4999	3.67	93.76	4.92	0.50	14111	0.71
.450		6.24	76.13	1.61	25	1265.65	100.00	9.36	0.57	13231	0.86

Certificate of Analysis

Pennsylvania Electric Company
Homer City Laboratory



Description:
CROWEBURG RAW COAL/LIBERATION
RUN #90051900
41001 CRUSHED TO 100M X 0

Lab No.: 900700475
From: CQ INC
Sampled: / /
Gross Wt.: 20.1705 Kg

FLOAT/SINK OF 0.075 BY 0.000 mm FRACTION REPRESENTING 60.50 % OF THE TOTAL SAMPLE

GRAVITY		DIRECT					CUMULATIVE FLOAT				
SINK	FLOAT	WT %	ASH	SULFUR	BTU/LB	SO2/MBTU	WT %	ASH	SULFUR	BTU/LB	SO2/MBTU
	1.250	17.96	1.10	0.51	14665	0.69	17.96	1.10	0.51	14665	0.69
.250	1.300	17.30	2.09	0.52	14431	0.72	35.26	1.59	0.51	14550	0.70
.300	1.350	21.83	2.92	0.51	14490	0.70	57.09	2.10	0.51	14527	0.70
.350	1.400	11.15	5.47	0.52	13934	0.75	68.24	2.65	0.51	14430	0.71
.400	1.600	12.14	11.28	0.57	13016	0.88	80.38	3.95	0.52	14217	0.73
.600	1.600	3.86	25.39	0.65	10716	1.21	84.23	4.93	0.53	14056	0.75
.800	2.000	1.90	41.09	0.86	7705	2.22	85.23	5.36	0.53	13982	0.76
.000	2.450	2.68	72.72	0.70	2909	4.84	87.92	7.41	0.54	13644	0.79
.450		11.06	80.42	2.38	527	11.22	100.00	16.23	0.76	12058	1.26

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Certificate of Analysis

Pennsylvania Electric Company
Homer City Laboratory



Description:
CROWEBURG RAW COAL/LIBERATION
RUN #90051900
41001 CRUSHED TO 100M X 0

Lab No.: 900700475
From: CQ INC
Sampled: / /
Gross Wt.: 20.1705 Kg

COMPOSITE WASHABILITY ANALYSIS OF PLUS BY 0.000 mm MATERIAL

GRAVITY		DIRECT					CUMULATIVE FLOAT				
SINK	FLOAT	WT %	ASH	SULFUR	BTU/LB	SO2/MBTU	WT %	ASH	SULFUR	BTU/LB	SO2/MBTU
	1.250	27.50	1.16	0.48	14711	0.65	27.50	1.16	0.48	14711	0.65
1.250	1.300	20.26	2.35	0.50	14438	0.69	47.77	1.67	0.49	14595	0.67
1.300	1.350	19.00	3.53	0.51	14367	0.71	66.77	2.20	0.49	14530	0.68
1.350	1.400	8.84	6.77	0.53	13750	0.78	75.61	2.73	0.50	14439	0.69
1.400	1.600	8.89	12.53	0.60	12773	0.93	84.50	3.80	0.51	14264	0.71
1.600	1.800	3.00	27.60	0.66	10393	1.26	87.49	4.62	0.51	14131	0.73
1.800	2.000	5.61	41.09	0.86	7705	2.22	88.10	4.87	0.52	14087	0.73
2.000	2.450	2.13	69.37	0.75	3402	4.47	90.23	6.39	0.52	13835	0.75
2.450		9.77	79.34	2.18	395	110.22	100.00	13.52	0.68	12522	1.09

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Certificate of Analysis

Pennsylvania Electric Company
Homer City Laboratory



Description:
CROWBORO RAW COAL/LIBERATION
RUN #90051900
41001 CRUSHED TO 100M X 0

Lab No.: 900700475
From: CQ INC
Sampled: / /
Gross Wt.: 20.1705 Kg

COMPOSITE SIZE DISTRIBUTION ANALYSIS

SIZE IN mm		-----DIRECT-----					-----CUMULATIVE RETAINED-----				
ASSED	RETAIN	WT %	ASH	SULFUR	BTU/LB	SO2/MBTU	WT %	ASH	SULFUR	BTU/LB	SO2/MBTU
	0.075	39.50	9.36	0.57	13231	0.86	39.50	9.36	0.57	13231	0.86
0.075		60.50	16.23	0.76	12058	1.26	100.00	13.52	0.68	12522	1.09

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October 22, 1990

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Certificate of Analysis

Pennsylvania Electric Company
Homer City Laboratory



Description:
CROWBORO RAW COAL/LIBERATION
RUN #90051900
41001 CRUSHED TO 100M X 0
TOTAL SAMPLE

Lab No.: 900700475
From: CQ INC
Sampled: / /
Gross Wt.: 20.1705 Kg

PARAMETER	AS RECEIVED	MOISTURE FREE
% Ash	12.38	13.69
% Total Moisture	9.52	

APPENDIX D

Wyodak Seams Raw Coal Liberation Data

January 25, 1991

P.O. Box 29
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412-479-9011



Certificate of Analysis
WASHABILITY ANALYSIS

Pennsylvania Electric Company
Homer City Laboratory



Description:
WYOMING-WYODAK SEAMS #90092400
RAW COAL LIBERATION
41001 CRUSHED TO 3/4" X 0

Lab No.: 901100015
From: CQ INC
Sampled: 09/25/90
Gross Wt.: 665.4000 Kg

SIZE IN mm		DIRECT					CUMULATIVE RETAINED				
ASSD	RETAIN	WT %	ASH	SULFUR	BTU/LB	SO2/MBTU	WT %	ASH	SULFUR	BTU/LB	SO2/MBTU
	19.000	0.96	6.70	0.56	11870	0.94	0.96	6.70	0.56	11870	0.94
19.000	5.500	31.52	5.86	0.56	12062	0.92	32.49	5.88	0.56	12056	0.92
9.500	0.600	34.62	6.26	0.58	11999	1.01	87.10	6.12	0.59	12020	0.97
0.600	0.150	4.76	7.44	1.02	11591	1.75	91.86	6.19	0.61	12003	1.01
0.150	0.075	1.76	9.43	1.04	11494	1.90	93.64	6.25	0.62	11994	1.03
0.075		6.36	17.60	0.64	11221	1.98	100.00	6.97	0.62	11980	1.04

Ash results reported on an SO₂-free basis.

Results reported on Dry
Basis and normalized to 100%
Screen sizes are square hole, Tyler
mesh unless designated otherwise.

Page 1 of 7

Approved: Om. Glesne

Date: JAN 25 1991

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January 25, 1991

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412-479-9011



Certificate of Analysis

Pennsylvania Electric Company
Homer City Laboratory



Description:
WYOMING-WYODAK SEAMS #90092400
RAW COAL LIBERATION
41001 CRUSHED TO 3/4" X 0

Lab No.: 901100015
From: CQ INC
Sampled: 09/25/90
Gross Wt.: 665.4000 Kg

FLOAT/SINK OF PLUS BY 0.600 mm FRACTION REPRESENTING 87.10 % OF THE TOTAL SAMPLE

GRAVITY		DIRECT					CUMULATIVE FLOAT				
SINK	FLOAT	WT %	ASH	SULFUR	BTU/LB	SO2/MBTU	WT %	ASH	SULFUR	BTU/LB	SO2/MBTU
	1.250	10.99	3.85	0.47	12367	0.76	10.99	3.85	0.47	12367	0.76
.250	1.300	73.86	4.56	0.46	12150	0.76	84.85	4.47	0.46	12178	0.76
.300	1.350	6.97	6.67	0.55	11676	0.93	91.81	4.64	0.47	12155	0.77
.350	1.400	3.99	9.07	0.66	11426	1.16	95.80	4.82	0.48	12125	0.79
.400	1.600	2.86	24.60	0.92	9275	1.98	98.65	5.40	0.49	12042	0.81
.600	1.800	0.70	50.92	1.07	5866	3.64	99.36	5.72	0.49	11996	0.82
.800	2.000	0.30	64.02	1.27	3962	6.39	99.66	5.89	0.50	11974	0.83
.000	2.450	0.05	68.32	3.11	3186	19.50	99.72	5.93	0.50	11969	0.83
.450		0.28	71.17	6.57	1835	71.47	100.00	6.11	0.51	11940	0.86

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Certificate of Analysis

Pennsylvania Electric Company
Homer City Laboratory



Description:
WYOMING-WYODAK SEAMS #90092400
RAW COAL LIBERATION
41001 CRUSHED TO 3/4" X 0

Lab No.: 901100015
From: CG INC
Sampled: 09/25/90
Gross Wt.: 665.4000 Kg

FLOAT/SINK OF 0.600 BY 0.150 mm FRACTION REPRESENTING 4.76 % OF THE TOTAL SAMPLE

GRAVITY		DIRECT					CUMULATIVE FLOAT				
SINK	FLOAT	WT %	ASH	SULFUR	BTU/LB	SO2/MBTU	WT %	ASH	SULFUR	BTU/LB	SO2/MBTU
	1.250		0.00	0.00	0	0.00					
.250	1.300	4.66	3.66	0.60	13188	0.91	4.66	3.66	0.60	13188	0.91
.300	1.350	58.45	3.91	0.46	12051	0.76	63.11	3.69	0.47	12135	0.78
.350	1.400	25.52	5.30	0.47	11467	0.75	88.63	4.30	0.47	12057	0.76
.400	1.600	7.26	13.80	0.79	10877	1.48	95.89	5.02	0.49	11952	0.83
.600	1.800	1.01	78.49	2.04	7627	0.34	96.90	5.34	0.51	11907	0.86
.800	2.000	0.56	48.15	3.59	5660	14.18	97.46	5.59	0.53	11870	0.90
.000	2.450	1.83	26.68	4.63	3916	41.20	98.31	6.04	0.61	11803	1.03
.450		1.69	67.52	17.32	2805	153.54	100.00	7.09	0.89	11651	1.53

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January 25, 1991

P.O. Box 29
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Certificate of Analysis

Pennsylvania Electric Company
Homer City Laboratory



Description:
WYOMING-WYODAK SEAMS #90092400
RAW COAL LIBERATION
41001 CRUSHED TO 3/4" X 0

Lab No.: 901100015
From: CG INC
Sampled: 09/25/90
Gross Wt.: 665.4000 Kg

FLOAT/SINK OF 0.150 BY 0.075 mm FRACTION REPRESENTING 1.78 % OF THE TOTAL SAMPLE

GRAVITY		DIRECT					CUMULATIVE FLOAT				
SINK	FLOAT	WT %	ASH	SULFUR	BTU/LB	SO2/MBTU	WT %	ASH	SULFUR	BTU/LB	SO2/MBTU
	1.250		0.00	0.00	0	0.00					
.250	1.300	10.98	3.30	0.58	12590	0.92	10.98	3.30	0.58	12590	0.92
.300	1.350	25.86	4.01	0.48	11953	0.81	36.84	3.79	0.51	12143	0.84
.350	1.400	25.24	4.40	0.45	11349	0.79	62.07	4.04	0.49	11620	0.82
.400	1.600	33.49	12.12	0.53	10752	0.98	95.56	6.87	0.50	11446	0.87
.600	1.800	1.44	30.48	1.16	8234	2.81	97.00	7.22	0.51	11399	0.89
.800	2.000		0.00	0.00	0	0.00					
.000	2.450	0.80	55.85	4.86	4728	20.54	97.80	7.62	0.55	11344	0.96
.450		2.20	75.33	15.58	1735	144.15	100.00	9.11	0.89	11132	1.59



Certificate of Analysis

Pennsylvania Electric Company
Homer City Laboratory



Description:
WYOMING-WYODAK SEAMS #90092400
RAW COAL LIBERATION
41001 CRUSHED TO 3/4" X 0

Lab No.: 901100015
From: CG INC
Sampled: 09/25/90
Gross Wt.: 665.4000 Kg

FLOAT/SINK OF 0.075 BY 0.000 mm FRACTION REPRESENTING 6.36 % OF THE TOTAL SAMPLE

GRAVITY		DIRECT					CUMULATIVE FLOAT				
SINK	FLOAT	WT %	ASH	SULFUR	BTU/LB	SO2/MBTU	WT %	ASH	SULFUR	BTU/LB	SO2/MBTU
	1.250		0.00	0.00	0	0.00					
250	1.300		0.00	0.00		0.00					
300	1.350	3.83	4.68	0.61	12519	0.97	3.83	4.68	0.61	12519	0.97
350	1.400	22.18	5.32	0.47	11757	0.80	26.02	5.27	0.45	11870	0.82
400	1.450	47.83	12.07	0.41	10907	0.75	73.84	9.68	0.44	11247	0.78
500	1.800	15.80	24.05	0.41	8713	0.95	89.64	12.35	0.43	10778	0.80
600	2.000	3.39	41.05	0.62	6305	1.97	94.03	13.40	0.44	10617	0.83
800	2.450	2.22	65.05	1.44	2572	5.67	96.25	14.69	0.46	10440	0.85
450		3.73	65.32	5.19	855	137.75	100.00	17.34	0.68	10082	1.34



Certificate of Analysis

Pennsylvania Electric Company
Homer City Laboratory



Description:
WYOMING-WYODAK SEAMS #90092400
RAW COAL LIBERATION
41001 CRUSHED TO 3/4" X 0

Lab No.: 901100015
From: CG INC
Sampled: 09/25/90
Gross Wt.: 665.4000 Kg

COMPOSITE WASHABILITY ANALYSIS OF PLUS 0.000 mm MATERIAL

GRAVITY		DIRECT					CUMULATIVE FLOAT				
SINK	FLOAT	WT %	ASH	SULFUR	BTU/LB	SO2/MBTU	WT %	ASH	SULFUR	BTU/LB	SO2/MBTU
	1.250	9.57	3.85	0.47	12367	0.76	9.57	3.85	0.47	12367	0.76
1.250	1.300	64.75	4.56	0.46	12154	0.76	74.32	4.47	0.46	12182	0.76
1.300	1.350	4.55	5.69	0.52	11947	0.87	83.87	4.61	0.47	12155	0.77
1.350	1.400	6.55	7.24	0.57	11573	0.90	90.42	4.80	0.48	12113	0.79
1.400	1.600	6.47	17.90	0.64	10254	1.24	96.89	5.61	0.49	11989	0.81
1.600	1.800	1.75	33.83	0.70	7683	1.81	98.64	6.11	0.49	11912	0.82
1.800	2.000	0.51	53.65	1.14	5051	4.52	99.15	6.36	0.49	11877	0.83
2.000	2.450	0.24	66.57	3.31	3271	20.21	99.39	6.50	0.50	11856	0.85
2.450		0.61	76.57	8.46	1590	106.37	100.00	6.93	0.55	11794	0.93



Certificate of Analysis

Pennsylvania Electric Company
Homer City Laboratory



Description:
WYOMING-WYODAK SEAMS #90092400
RAW COAL LIBERATION
41001 CRUSHED TO 3/4" X 0

Lab No.: 901100015
From: CQ INC
Sampled: 09/25/90
Gross Wt.: 665.4000 Kg

COMPOSITE SIZE DISTRIBUTION ANALYSIS

SIZE IN mm		DIRECT					CUMULATIVE RETAINED				
TESTED	RETAIN	WT %	ASH	SULFUR	BTU/LB	SO2/MBTU	WT %	ASH	SULFUR	BTU/LB	SO2/MBTU
0.600	0.600	87.10	6.11	0.51	11940	0.86	87.10	6.11	0.51	11940	0.86
0.600	0.150	4.76	7.09	0.89	11651	1.93	91.86	6.16	0.53	11925	0.90
0.150	0.075	1.78	9.11	0.89	11132	1.93	93.64	6.22	0.54	11910	0.91
0.075		6.36	17.34	0.68	10082	1.93	100.00	6.23	0.55	11794	0.93

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January 25, 1991

P.O. Box 29
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Certificate of Analysis

Pennsylvania Electric Company
Homer City Laboratory



Description:
WYOMING-WYODAK SEAMS #90092400
RAW COAL LIBERATION
41001 CRUSHED TO 3/4" X 0
TOTAL SAMPLE

Lab No.: 901100015
From: CQ INC
Sampled: 09/25/90
Gross Wt.: 665.4000 Kg

PARAMETER	AS RECEIVED	MOISTURE FREE
% Ash	4.87	7.03
% Total Moisture	30.79	



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ANALYTICAL ANALYSIS

Pennsylvania Electric Company
Homer City Laboratory



Description:
WYOMING-WYODAK SEAMS #90192400
RAW COAL LIBERATION
41001 CRUSHED TO 3/8" X 1

Lab No.: 901100016
From: CG INC
Sampled: 09/25/90
Gross Wt.: 665.2000 Kg

SIZE IN MM		DIRECT					CUMULATIVE RETAINED				
ASSED	RETAIN	WT %	ASH	SULFUR	BTU/LB	SO2/MBTU	WT %	ASH	SULFUR	BTU/LB	SO2/MBTU
	9.500	4.59	6.28	0.54	12018	0.90	4.59	6.28	0.54	12018	0.90
9.500	0.600	81.00	6.04	0.55	12000	0.92	86.67	6.05	0.55	12001	0.92
0.600	0.150	9.57	6.85	0.95	11843	1.82	91.64	6.10	0.58	11992	0.96
0.150	0.075	1.61	8.39	1.07	11412	1.78	93.25	6.14	0.58	11982	0.97
0.075		6.75	16.37	0.66	10297	1.85	100.00	6.33	0.59	11868	0.99

Ash results reported on an ash-free basis.

Results reported on Dry
Basis and normalized to 100%
Screen sizes are square hole, Tyler
mesh unless designated otherwise.

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Approved:

DM Glassney

Date: JAN 31 1991

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Certificate of Analysis

Pennsylvania Electric Company
Homer City Laboratory



Description:
WYOMING-WYODAK SEAMS #90192400
RAW COAL LIBERATION
41001 CRUSHED TO 3/8" X 1

Lab No.: 901100016
From: CG INC
Sampled: 09/25/90
Gross Wt.: 665.2000 Kg

FLOAT/SINK OF PLUS BY 0.600 mm FRACTION REPRESENTING 86.07 % OF THE TOTAL SAMPLE

GRAVITY		DIRECT					CUMULATIVE FLOAT				
SINK	FLOAT	WT %	ASH	SULFUR	BTU/LB	SO2/MBTU	WT %	ASH	SULFUR	BTU/LB	SO2/MBTU
	1.250	18.59	4.03	0.44	12375	0.72	18.59	4.03	0.44	12375	0.72
.250	1.300	38.54	4.39	0.43	12263	0.70	57.13	4.27	0.43	12299	0.70
.300	1.350	32.71	5.16	0.43	12056	0.71	89.84	4.60	0.43	12211	0.71
.350	1.400	5.60	8.81	0.60	11496	1.04	95.43	4.84	0.44	12169	0.73
.400	1.600	3.20	27.37	0.81	9268	1.75	98.63	5.58	0.45	12075	0.75
.600	1.800	0.67	51.02	0.98	8780	3.38	99.31	5.88	0.46	12032	0.76
.800	2.000	0.29	64.74	1.94	4034	5.66	99.60	6.06	0.46	12009	0.77
.000	2.450	0.24	71.62	4.55	3027	30.05	99.84	6.21	0.47	11967	0.79
.450		0.16	69.19	10.65	1766	120.62	100.00	6.31	0.49	11970	0.82

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Pennsylvania Electric Company
Homer City Laboratory



Description:
WYOMING-WYODAK SEAMS #90092400
RAW COAL LIBERATION
41001 CRUSHED TO 3/8" X 0

Lab No.: 901100016
From: CQ INC
Sampled: 09/25/90
Gross Wt.: 665.2000 Kg

FLOAT/SINK OF 0.600 BY 0.150 mm FRACTION REPRESENTING 5.57 % OF THE TOTAL SAMPLE

GRAVITY		DIRECT					CUMULATIVE FLOAT				
SINK	FLOAT	WT %	ASH	SULFUR	BTU/LB	SO2/MBTU	WT %	ASH	SULFUR	BTU/LB	SO2/MBTU
1.250	1.250	1.10	3.70	0.56	12903	0.87	1.10	3.70	0.56	12903	0.87
.250	1.300	1.67	3.88	0.62	12827	0.96	2.77	3.80	0.59	12857	0.92
.300	1.350	15.49	4.05	0.51	12311	0.83	15.26	4.25	0.52	12396	0.84
.350	1.400	64.31	4.17	0.38	10790	0.64	82.57	4.15	0.41	12126	0.62
.400	1.450	15.47	10.20	0.56	11157	1.02	96.05	4.99	0.44	11984	0.73
.600	1.800	1.20	33.47	2.15	7759	1.54	97.25	5.35	0.46	11932	0.77
.800	2.100	0.62	49.37	3.46	6608	2.67	97.87	5.63	0.48	11851	0.80
.900	2.400	0.13	60.00	4.56	3578	4.02	98.70	6.63	0.54	11625	0.92
.950		1.30	65.90	10.35	5325	11.23	100.00	6.67	0.79	11714	1.33

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January 31, 1991

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Pennsylvania Electric Company
Homer City Laboratory



Description:
WYOMING-WYODAK SEAMS #90092400
RAW COAL LIBERATION
41001 CRUSHED TO 3/8" X 0

Lab No.: 901100016
From: CQ INC
Sampled: 09/25/90
Gross Wt.: 665.2000 Kg

FLOAT/SINK OF 0.150 BY 0.075 mm FRACTION REPRESENTING 1.61 % OF THE TOTAL SAMPLE

GRAVITY		DIRECT					CUMULATIVE FLOAT				
SINK	FLOAT	WT %	ASH	SULFUR	BTU/LB	SO2/MBTU	WT %	ASH	SULFUR	BTU/LB	SO2/MBTU
1.250	1.250		0.00	-0.00	0	0.00					
.250	1.300	0.79	3.47	0.37	13515	0.54	0.79	3.47	0.37	13515	0.54
.300	1.350	15.04	3.61	0.46	12002	0.77	15.83	3.80	0.45	12077	0.75
.350	1.400	52.56	4.01	0.39	11735	0.66	68.39	3.96	0.40	11815	0.68
.400	1.450	27.03	9.02	0.48	11039	0.87	95.42	5.39	0.42	11595	0.73
.600	1.800	1.32	29.71	1.07	7568	0.68	96.74	5.72	0.43	11545	0.75
.800	2.000		0.00	0.00	0	0.00					
.900	2.450	1.09	54.50	4.32	4772	16.11	97.83	6.27	0.48	11470	0.83
.950		2.17	74.46	15.46	2183	141.58	100.00	7.75	0.80	11269	1.42

January 31, 1991

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Homer City LaboratoryDescription:
WYOMING-WYODAK SEAMS #50892400
RAW COAL LIBERATION
41001 CRUSHED TO 28M X 0Lab No.: 901100017
From: CG INC
Sampled: 09/25/90
Gross Wt.: 40.8300 Kg

FLOAT/SINK OF 0.150 BY 0.075 MM FRACTION REPRESENTING 19.62 % OF THE TOTAL SAMPLE

GRAVITY SINK FLOAT	DIRECT					CUMULATIVE FLOAT				
	WT %	ASH	SULFUR	BTU/LB	SO2/MBTU	WT %	ASH	SULFUR	BTU/LB	SO2/MBTU
250 1.250		0.00	0.00	0	0.00					
250 1.350	4.39	3.00	0.55	10357	0.89	4.39	3.29	0.55	12357	0.89
300 1.350	28.00	3.34	0.44	11980	0.74	32.40	3.33	0.46	12031	0.76
350 1.400	53.50	5.06	0.43	11900	0.72	85.90	4.42	0.44	11955	0.74
400 1.600	11.43	10.54	0.55	10137	0.97	97.33	5.14	0.46	11935	0.77
500 1.800		0.00	0.00	0	0.00					
800 2.000	1.36	10.56	1.21	8364	0.57	98.70	5.60	0.47	11763	0.79
900 2.450		0.00	0.00	0	0.00					
950	1.38	71.04	11.04	2193	111.43	100.00	6.46	0.61	11637	1.04

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January 31, 1991

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Homer City LaboratoryDescription:
WYOMING-WYODAK SEAMS #96092400
RAW COAL LIBERATION
41001 CRUSHED TO 28M X 0Lab No.: 901100017
From: CG INC
Sampled: 09/25/90
Gross Wt.: 40.8300 Kg

FLOAT/SINK OF 0.075 BY 0.030 MM FRACTION REPRESENTING 16.02 % OF THE TOTAL SAMPLE

GRAVITY SINK FLOAT	DIRECT					CUMULATIVE FLOAT				
	WT %	ASH	SULFUR	BTU/LB	SO2/MBTU	WT %	ASH	SULFUR	BTU/LB	SO2/MBTU
250 1.250		0.00	0.00	0	0.00					
250 1.350		0.00	0.00	0	0.00					
300 1.350	9.30	4.21	0.51	12190	0.84	9.30	4.28	0.51	12190	0.84
350 1.400	52.33	4.56	0.42	12163	0.70	61.64	4.52	0.44	12167	0.72
400 1.600	24.84	10.95	0.43	10466	0.75	86.48	6.57	0.43	11759	0.74
500 1.800	3.18	28.67	0.65	8250	1.58	89.66	7.32	0.44	11640	0.76
600 2.000	1.17	43.67	0.86	6300	2.72	90.83	7.77	0.45	11574	0.77
900 2.450	2.16	73.37	1.21	2548	9.52	96.99	9.23	0.46	11374	0.82
950	3.02	85.43	6.44	914	151.61	100.00	11.53	0.66	11058	1.19



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Pennsylvania Electric Company
Homer City Laboratory



Description:

WYOMING-WYODAK SLAMS #90192400
RAW COAL LIBERATION
41001 CRUSHED TO 28M X 0

Lab No.: 901100017

From: CQ INC

Sampled: 09/25/90

Gross Wt.: 40.8300 Kg

COMPOSITE WASHABILITY ANALYSIS OF PLUS 50 0.000 mm MATERIAL

GRAVITY		DIRECT					CUMULATIVE FLOAT				
SINK	FLOAT	WT %	ASH	SULFUR	BTU/LB	SO2/MBTU	WT %	ASH	SULFUR	BTU/LB	SO2/MBTU
1.250	1.300	7.72	3.01	0.51	12456	0.83	7.72	3.01	0.51	12456	0.83
1.300	1.350	35.64	3.20	0.40	12000	0.60	43.36	3.77	0.42	12122	0.69
1.350	1.400	41.66	4.53	0.40	12025	0.60	85.03	4.34	0.41	12074	0.63
1.400	1.600	11.42	11.27	0.59	10977	0.90	96.45	5.21	0.43	11932	0.71
1.600	1.800	1.16	12.85	0.91	7937	2.00	97.61	5.83	0.43	11865	0.73
1.800	2.000	0.76	94.55	1.48	6090	4.80	98.36	5.84	0.44	11840	0.74
2.000	2.450	0.11	65.70	2.12	3913	10.50	98.96	6.23	0.46	11785	0.77
2.450		1.02	76.27	0.94	1686	116.37	100.00	6.05	0.55	11662	0.95

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Homer City Laboratory



Description:

WYOMING-WYODAK SLAMS #90092400
RAW COAL LIBERATION
41001 CRUSHED TO 28M X 0

Lab No.: 901100017

From: CQ INC

Sampled: 09/25/90

Gross Wt.: 40.8300 Kg

COMPOSITE SIZE DISTRIBUTION ANALYSIS

SIZE IN mm		DIRECT					CUMULATIVE RETAINED				
SED	RETAIN	WT %	ASH	SULFUR	BTU/LB	SO2/MBTU	WT %	ASH	SULFUR	BTU/LB	SO2/MBTU
	0.150	64.35	5.96	0.51	11851	0.86	64.35	5.96	0.51	11851	0.86
	0.150	19.62	6.46	0.61	11637	1.04	83.96	6.08	0.53	11801	0.90
	0.075	16.02	11.53	0.65	11058	1.19	100.00	6.95	0.55	11682	0.95

APPENDIX E

Plant and Component Yields

PLANT YIELD CALCULATION - HMC/WOC/FF FLOWSHEET 1

PLANT FEED (tph)		15.15
+28M (Wt %)	41003 - Plant Feed	84.29
HMC YIELD		
HMC Feed (tph)		12.77
Refuse Ash (Wt %)	41040 - Refuse D&R (+28M)	62.92
Clean Coal Ash (Wt %)	41037 - CC D&R (+28M)	4.95
Feed Ash (Wt %)	41004 - Deslime OF (+28M)	10.76
Yield - Ash Balance (Wt %)		89.98
Yield (tph)		11.49
WOC YIELD		
WOC Feed (tph)		2.38
Refuse Ash (Wt %)	41011 - Second WOC UF	49.00
Clean Coal Ash (Wt %)	41007 - Prim WOC OF	27.61
Feed Ash (Wt %)	41005 - Deslime UF	30.69
Yield - Ash Balance (Wt %)		85.60
Yield (tph)		2.04
VARISIEVE YIELD		
Varisieve Feed (tph)		2.04
Refuse Ash (Wt %)	Varisieve Effluent	46.23
Clean Coal Ash (Wt %)	Varisieve Cake	7.00
Feed Ash (Wt %)	41007 - Prim WOC OF	27.61
Yield - Ash Balance (Wt %)		47.46
Yield (tph)		0.97
THICK CYCLONE YIELD		
Thick Cyclone Feed (tph)		1.07
Refuse Ash (Wt %)	41026 - Thick Cyclone OF	49.43
Clean Coal Ash (Wt %)	41028 - FF Feed	38.65
Feed Ash (Wt %)	Varisieve Effluent	46.23
Yield - Ash Balance (Wt %)		29.68
Yield (tph)		0.32
FF YIELD		
FF Feed (tph)		0.32
Refuse Ash (Wt %)	41030 - FF UF	41.66
Clean Coal Ash (Wt %)	41029 - FF OF	8.61
Feed Ash (Wt %)	41028 - FF Feed	38.65
Yield - Ash Balance (Wt %)		9.11
Yield (tph)		0.03
BIRD CENTRIFUGE YIELD		
Bird Feed (tph)		1.00
Refuse Ash (Wt %)	Bird Effluent	58.95
Clean Coal Ash (Wt %)	Bird Product	14.89
Feed Ash (Wt %)	(Calculated)	7.05
Yield - Ash Balance (Wt %)		117.80
Yield - Corrected		100.00
Yield (tph)		1.00
PLANT YIELD (tph)		12.49
PLANT YIELD (Wt %)		82.42

PLANT YIELD CALCULATION - HMC/WOC/FF FLOWSHEET 2

PLANT FEED (tph)		15.06	1.0
+28M (Wt %)	41003 - Plant Feed	80.92	1.6
HMC YIELD			
HMC Feed (tph)		12.91	1.3
Refuse Ash (Wt %)	41040 - Refuse D&R (+28M)	49.53	1.1
Clean Coal Ash (Wt %)	41037 - CC D&R (+28M)	4.40	1.5
Feed Ash (Wt %)	41004 - Deslime OF (+28M)	8.66	1.0
Yield - Ash Balance (Wt %)		90.56	1.9
Yield (tph)		11.04	1.6
WOC YIELD			
WOC Feed (tph)		2.87	1.7
Refuse Ash (Wt %)	41011 - Second WOC UF	42.68	1.5
Clean Coal Ash (Wt %)	41007 - Prim WOC OF	26.04	1.3
Feed Ash (Wt %)	41005 - Deslime UF	31.63	1.3
Yield - Ash Balance (Wt %)		66.41	1.9
Yield (tph)		1.91	1.6
VARISIEVE YIELD			
Varisieve Feed (tph)		1.91	1.6
Refuse Ash (Wt %)	Varisieve Effluent	43.78	1.4
Clean Coal Ash (Wt %)	Varisieve Cake	4.46	1.9
Feed Ash (Wt %)	41007 - Prim WOC OF	26.04	1.3
Yield - Ash Balance (Wt %)		45.12	1.9
Yield (tph)		0.86	1.3
THICK CYCLONE YIELD			
Thick Cyclone Feed (tph)		1.05	1.3
Refuse Ash (Wt %)	41026 - Thick Cyclone OF*	46.57	1.2
Clean Coal Ash (Wt %)	41028 - FF Feed	37.57	1.4
Feed Ash (Wt %)	Varisieve Effluent	43.78	1.4
Yield - Ash Balance (Wt %)		31.00	1.5
Yield (tph)		0.32	1.4
FF YIELD			
FF Feed (tph)		0.32	1.4
Refuse Ash (Wt %)	41030 - FF UF	69.35	1.4
Clean Coal Ash (Wt %)	41029 - FF OF	8.40	1.5
Feed Ash (Wt %)	41028 - FF Feed	37.57	1.4
Yield - Ash Balance (Wt %)		52.14	1.3
Yield (tph)		0.17	1.0
BIRD CENTRIFUGE YIELD			
Bird Feed (tph)		1.03	1.4
Refuse Ash (Wt %)	Bird Effluent	45.17	1.0
Clean Coal Ash (Wt %)	Bird Product	5.03	1.0
Feed Ash (Wt %)	(Calculated)	5.11	1.7
Yield - Ash Balance (Wt %)		99.81	1.9
Yield - Corrected		99.81	1.0
Yield (tph)		1.03	1.4
PLANT YIELD (tph)		12.06	1.1
PLANT YIELD (Wt %)		80.11	1.8

* Calculated